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Your Deceptive Mind: A Scientific Guide to Critical Thinking Skills

Course Guidebook

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Professor Steven Novella is an Academic Neurologist at Yale School of Medicine. He is active in medical education at every level of experience, including patients, the public, medical students, and continuing education for medical professionals. He also performs clinical research in his specialty area, publishing on amyotrophic lateral sclerosis, myasthenia gravis, and neuropathy.

Dr. Novella received his M.D. from Georgetown University and went on to complete residency training in neurology at Yale School of Medicine. He is also trained and board certified in the subspecialty of neuromuscular disorders, which continues to be a focus of his practice. Although he treats all types of neurological disorders, his clinical focus includes headaches and diseases of nerves and muscles.

Dr. Novella is the president and cofounder of the New England Skeptical Society, a nonprofit educational organization dedicated to promoting the public understanding of science. He is also the host and producer of their popular weekly science podcast, *The Skeptics' Guide to the Universe*. This award-winning science show (winner of the People's Choice Podcast Award in education for 2009 and in science for 2010–2011) explores the latest science discoveries, the presentation of science in the mainstream media, public understanding and attitudes toward science, philosophy of science, and critical thinking. Dr. Novella has also recorded *Medical Myths, Lies, and Half-Truths: What We Think We Know May Be Hurting Us* with The Great Courses.

Dr. Novella was appointed in 2009 as a fellow of the Committee for Skeptical Inquiry, an international organization dedicated to the promotion of science and reason; he writes a regular column for their publication, the *Skeptical Inquirer*. Dr. Novella was also appointed in 2011 as the senior fellow of the

James Randi Educational Foundation and director of their Science-Based Medicine project. Dr. Novella maintains a personal blog, the award-winning *NeuroLogica Blog*, which is considered one of the top neuroscience blogs. On *NeuroLogica Blog*, he covers news and issues in neuroscience but also general science, scientific skepticism, philosophy of science, critical thinking, and the intersection of science with the media and society.

Dr. Novella is the founder and senior editor of *Science-Based Medicine*—a group medical and health blog with contributions from dozens of physicians and scientists. *Science-Based Medicine* is dedicated to promoting the highest standards of both basic and clinical science in medical practice. This prolific health blog is geared toward both the general public and health professionals. *Science-Based Medicine* is recognized as a top health blog and is increasingly influential in the ongoing discussion of the role of science in medicine. ■

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Your Deceptive Mind:
A Scientific Guide to Critical Thinking Skills

Scope:

Much of what we remember and believe is flawed or simply wrong. Our brains seem to constantly generate false observations, memories, and beliefs—and yet we tend to take the truth of our experiences for granted. In this course, you will learn the many ways in which our human brains deceive us and lead us to conclusions that have little to do with reality. You will also learn strategies that can be used to combat the mind's many deceptions. This course explores what is called metacognition: thinking about thinking itself.

The first part of the course will cover the way we perceive the world around us. Everything we think we see, hear, and experience is not a direct recording of the outside world; instead, it is a construction. Information is filtered, distorted, compared, and confabulated—ultimately to be woven into a narrative that fits our assumptions about the world. Our experiences and thoughts are also filtered through our egos and the many emotional needs humans constantly feed.

Furthermore, everything we think and experience becomes a memory, which is further constructed, altered, and fused. We rely upon our memories as if they were accurate recordings of the past, but the evidence shows that we should be highly suspicious of even the most vivid and confident memories. We don't recall memories as much as we reconstruct and update them, altering the information every time we access it. Our brains also fill in gaps by making up information as needed.

Additionally, a host of logical flaws and cognitive biases plague our thinking, unless we are specifically aware of and avoid those fallacies. In this course, you will explore logical fallacies and cognitive biases in detail, learning how they affect thinking in often subtle ways. You will also learn about heuristics,

which are mental shortcuts we tend to take in thinking; these shortcuts may be efficient in most circumstances, but they can also lead us astray.

Our brains have other interesting strengths and weaknesses that can further inform our thinking. We are generally very good at pattern recognition—so good that we often see patterns that are not actually there. However, many of us are inherently poor at probability and statistics, and this innumeracy opens us up to deception and errors in thinking. Perhaps our greatest weakness is our susceptibility to delusion, the ability to hold a false belief against all evidence.

The second part of the course goes beyond how our brains distort reality to discuss how you can specifically use critical thinking skills and tools to combat the deceptions of your mind. The philosophy and practice of critical thinking and science are the tools that humans have slowly and carefully honed over many millennia to compensate for the many flaws in our brains.

In addition, the second section covers the history of science and discusses how to tell the difference between good science, bad science, and pseudoscience that is so flawed that it's not real science. In this section, you will encounter many examples of pseudoscience in which various attempts at new discoveries went wrong. The lecture on scientific blunders also discusses great scientific mistakes in history and the lessons that can be learned from them.

In the final section of the course, you will learn how to apply critical thinking, knowledge of science, and knowledge of the mechanisms of self-deception to everyday practice. Then, you will discover the role of science and critical thinking in democracy, the need for high-quality science education, and how to skeptically approach the media. This section will partly be a primer on how not to get scammed or fooled.

By the end of the course, you will have a thorough understanding of what constitutes critical thinking and why we all so desperately need it. Left to our own devices—what psychologists call the default mode of human thinking—we will be subject to the vagaries of perception and memory and slaves to our emotional needs and biases.

The skills taught in this course will help you operate on the metacognitive level so that you are able to think about the process of your own thinking. The human brain is the universal tool by which we understand ourselves and the universe in which we live. By understanding the nature of human cognition and the methods of thinking clearly and critically, we can avoid common errors and make the best use of our minds. ■

The Necessity of Thinking about Thinking

Lecture 1

This course focuses on metacognition, or thinking about thinking itself, and it endeavors to give you the skills of critical thinking. Developing critical thinking skills is empowering and liberating, and it is a defense mechanism against the world that we live in. In this introductory lecture, the concept of metacognition will be introduced, and you will learn why it is necessary. In addition, an overview of the purpose of this course will be given with examples of the importance of critical thinking in everyday life.

Logic and Critical Thinking

- Science and belief permeate our lives; they permeate our culture and our civilization. We buy products every day that involve claims—either explicit or implicit—and we need to be able to evaluate those claims in order to make good purchasing decisions.

- We use **critical thinking** in order to think about how we run our civilization. We have to purchase health-care products and decide what foods to eat and what lifestyle changes to make in order to stay healthy. These claims are based upon evidence and **logic**, and we need critical thinking to be able to evaluate them properly.

- One of the premises of this course is that we are our brains. In essence, the brain is an organ that can think and is self-aware. It is not only the most complicated organ that we know about, but it may in fact be the most complicated thing in the universe that we know about. The brain can remember, feel, believe, calculate, extrapolate, infer, and deduce. It does everything that we think of as thinking.

- The brain is our universal tool and greatest strength. Most people believe that our intelligence is our greatest advantage over all the other creatures on this planet. However, the brain is also strangely deceptive and is the root of many of our flaws and weaknesses.

- This course will also explore human nature. Humans possess logic, but we are not inherently logical creatures. In addition to being logical, we are also highly emotional creatures; we tend to follow our evolved emotions and rationalizations. Our thoughts tend to follow a pathway of least resistance, which is not always the optimal pathway.

- Logic and critical thinking are, therefore, learned skills. While we have some inherent sense of logic, we are overwhelmingly emotional creatures. We have the capacity for logic, but logic and critical thinking are skills. We're not born as master critical thinkers—just as we're not born as violinists. Both are skills that need to be developed and practiced over many years.

Flaws in Human Thinking

- The inherent tendency of humans is to make many errors in thinking. One example is flaws in logic, which are called logical fallacies, in which we tend to make logical connections that are not **valid**, or real.

- Our thinking is also plagued with many false assumptions. Our heads are filled with knowledge that we think is true but is, in fact, false. Either these bits of knowledge are simply wrong, or they're assumptions that fall short of the truth.

- Our memories are also massively flawed. We tend to naively assume that our memories are an accurate, passive recorder of what has happened, but our memories are actually plagued with numerous flaws that make them highly unreliable.

- In psychology, **heuristics** are patterns of thinking. They're mental shortcuts that we tend to take that may be right much of the time but are wrong often enough that they quite frequently lead us astray.

- We compensate for all of these flaws in our brain's functioning by using **metacognition**, or thinking about thinking itself. A process called **scientific skepticism** involves systematic doubt—questioning everything that you think, the process of your thinking, and everything that you think you know.

- One component of critical thinking is basing your beliefs on actual evidence as opposed to wishful thinking, for example. The goal is to arrive at conclusions that are likely to be reliable as opposed to conclusions that are unreliable, but we also want to have a sense of how reliable our conclusions are.

- The scientific method is scientific skepticism—not just doubt, but a positive set of methods for examining reality. Essentially, science is a systematic way of comparing our ideas to external, objective data.

- In short, the goal of science is to lead us to conclusions that are actually true as opposed to conclusions that we simply wish are true. However, not all science is valid. Some science is so flawed that we call it **pseudoscience**.

- Science follows scientific methodology. It is not a set of beliefs, but it is a set of methods, and there are ways of defining that as well as distinguishing good science from bad science.

- The scientific method is based upon **methodological naturalism**, which is the philosophical term for the notion that natural effects have natural causes. In trying to model and understand the world, you cannot refer to supernatural or miraculous causes that don't have any testable cause in the natural world.

- All conclusions in science are provisional; there is no such thing as absolute metaphysical certitude. Not only do we have to assess what is likely to be true but also how confident we can be about that belief, knowing that we'll never quite reach absolute certainty.

- All of our beliefs are open to revision. When new data comes in, or maybe just a better way of interpreting data, we have to be open to revising what we thought we knew.

- Human beings are subject to **delusions**. Sometimes our thinking goes so far awry that we can invent our own reality or become

swept up in the beliefs of others. One common manifestation of this is a public panic.

- It's helpful to consider thinking as a process and to focus on the process rather than on any particular conclusion. Once we emotionally invest in a conclusion, humans are very good at twisting and rationalizing facts and logic in order to fit that desired conclusion. Instead, we should invest in the process and be very flexible when it comes to any conclusions.

On a daily basis, we need to use critical thinking to evaluate our decisions—such as which products to purchase.

- In addition, we are currently living not only in the age of information with the Internet, but we are living in the age of misinformation. There are many rumors that now spread faster than wildfire; they spread with the speed of electrons through the Internet.

- Whether they're innocent or malicious, myths are spread through the Internet in order for the people behind the myths to try to steal other people's money, lure them into a scam, or even influence their voting.

- We live in a capitalistic society, which means that every day we're subject to marketing claims that are highly motivated to misrepresent the facts or to give us a very specific perspective. Such claims try to influence our thoughts and behavior by engaging in persuasive speech and maybe even deception.

- As consumers, every day we have to sort through deliberately deceptive claims to figure out which ones are reliable and which ones aren't. Furthermore, many companies use pseudoscience or even antiscientific claims to back up their marketing and products, and that can seem very persuasive to someone who isn't skilled in telling real science from pseudoscience.

Thinking Critically

- Thinking critically is a process, and the first component is to examine all of the facts that you are assuming or that you think are true. Many of them may not be reliable, or they may be assumptions. You may not know whether they're true, but you're assuming they're true.

- You also need to examine your logic. Is the logic you're using legitimate, or is it flawed in some way? Perhaps it's systematically biased in a certain direction.

- In addition, you should try to become aware of your motivations. People are extremely good at rationalizing beliefs when they are motivated by a desire to believe a certain conclusion. Understanding your motivations will help you deconstruct that process and will give you the skills to discover conclusions that are more likely to be true, as opposed to the ones that you just wish to be true.

- Critical thinking also means thinking through the implications of a belief—that different beliefs about the world should all be compatible with each other. We have a tendency to compartmentalize, to have one belief walled off from all of our other beliefs, and therefore we insulate it from refutation. If you think about what else has to be true if a certain belief is true and whether both make sense, that is a good way to tell how plausible or how likely to be true a belief is.

- Additionally, you should check with others: No matter how developed your critical thinking skills are, you're still only one person, whose thinking is quirky and individual.

- You have a limited fund of knowledge and a limited perspective. In fact, your knowledge and perspective may be limited in ways that you're not aware. You don't know what you don't know. Therefore, if you check your beliefs with others, it increases the probability that any holes in your thinking will be covered up.

- When a large consensus on a specific claim is achieved, there's a greater chance that the consensus reflects reality than the process of an individual. A consensus may be systematically biased as well, but at least you're stepping out of the limitations of your knowledge.

- It's also important to be humble, which means knowing your limits. We tend to get into trouble when we assume we have expertise or knowledge that we don't have or when we don't question the limits of our knowledge.

- In addition, be comfortable with uncertainty. There are some things that we simply cannot know or that we currently do not know. There may be times when, after reviewing all the logic and evidence, our only conclusion is that we currently don't know.

- Critical thinking is a skill that can be learned and that can be reinforced by habit. The scientific approach to critical thinking is empirical. It is a way of testing our beliefs systematically against the real world. Once we develop our critical thinking skills and begin to examine our beliefs systematically, it can be extremely empowering.

- Critical thinking is, in fact, a defense mechanism against all the machinations that are trying to deceive us—whether for ideological, political, or marketing reasons. Critical thinking also liberates us from being weighed down by the many false beliefs, and perhaps mutually incompatible beliefs, that we tend to hold because of our emotional makeup.

Important Terms

critical thinking: Applying systematic logic and doubt to any claim or belief; thinking carefully and rigorously.

delusion: A fixed, false belief that is vigorously held even in the face of overwhelming contradictory evidence.

heuristic: A cognitive rule of thumb or mental shortcut that we subconsciously make that may be true much of the time but is not logically valid.

logic: A formal process or principle of reasoning.

metacognition: Thinking about thinking; examining the processes by which we think about and arrive at our own beliefs.

methodological naturalism: The philosophical assumptions that underlie scientific methodology; specifically, the assumption that all effects have natural causes.

pseudoscience: A practice that superficially resembles the process of science but distorts proper methodology to the point that it is fatally flawed and does not qualify as true science.

scientific skepticism: A comprehensive approach to knowledge that emphasizes critical thinking and science. Skepticism combines knowledge of philosophy of science, scientific methods, mechanisms of self-deception, and related fields to approach all claims to truth in a provisional and systematic way.

valid: An argument in which the logic is proper and not fallacious.

Suggested Reading

Gilovich, *How We Know What Isn't So*.

Sagan, *The Demon-Haunted World.*

Shermer, *Why People Believe Weird Things.*

Questions to Consider

1. Why is critical thinking important to the average person—and to society as a whole?

2. What are the neurological, psychological, and cultural barriers to critical thinking?

The Neuroscience of Belief

Lecture 2

This lecture will cover why people believe what they do. Humans are emotional creatures, and this has a powerful effect on our reasoning. In this lecture, you will learn about the neurological organization of the brain and how that relates to how you rationalize beliefs and are influenced by basic human desires and emotions. Additionally, you will learn what drives this human desire for belief and for the specific things you believe in. The hope is that by understanding what motivates humans, you will be able to transcend or at least mitigate the influence of those motivations.

Belief, Motivation, and Reason

- Our brains are belief machines. We are motivated to believe, especially those things that we want to believe.

- The **default mode** of human psychology is to arrive at beliefs for largely emotional reasons and then to employ our reason—more to justify those beliefs than to modify or arrive at those beliefs in the first place. Therefore, in many ways, we are slaves to our own emotions if we let ourselves be.

- It is helpful to try to understand this interaction between belief, motivation, and reason in the context of microanatomy, or understanding the way our brains are organized.

- The most recently evolved parts of our brain, specifically the frontal lobe portion of the **neocortex**, hierarchically can modify and control the earlier evolved, more primitive parts of our brain. The brain stem is the area associated with the most primitive functions.

- In addition to the most basic functions, such as breathing and maintaining balance while we walk, much of our cognition takes

place in our **subconscious**, or in the more primitive parts of our brain, which are also where our emotions are housed.

- Emotions essentially make quick decisions for us that are mostly adaptive, evolved strategies, including fear, lust, hunger, anxiety, disgust, happiness, and sadness. The idea is that emotions provide a direct behavioral motivation so that we don't have to calculate the risks of encountering a predator versus fleeing, for example. We simply experience the emotion of fear, and then we act upon that emotion.

- Psychologist Abraham Harold Maslow made perhaps the first attempt to classify the different emotional needs that people have, which are now known as Maslow's **hierarchy of needs**. In addition to basic emotions, we also have a set of higher psychological needs that we seek: We desire to be safe, to be loved, to have self-esteem, and to experience what Maslow called self-actualization.

- The primitive parts of our brain can experience hunger, but only our much more evolved neocortex can experience an emotion like the need for self-actualization.

- When we meet our psychological needs, our brain gives us a reward: It makes us feel good, which is another emotion. There is a basic punishment-and-reward system built into the hardwiring of our brain. When we do something that is likely to be advantageous evolutionarily, we feel good—we get a shot of dopamine to our reward centers.

Needs That Motivate

- The desire for control, or at least for the illusion or sense of control, is one need that motivates us. We don't like to feel as if we are victims of a capricious universe or as if we are helpless in the face of unseen forces or randomness. We like to think that we exert some control over ourselves, over the events that happen to us, and over our environment.

- One manifestation of this desire for control is belief in superstitions. We tend to develop beliefs that if we engage in a certain activity, it will protect us or enable us to succeed. Superstitious practices give us the illusion that we can exert some control over otherwise random events.

- We also have a desire for simplicity because the simpler things are, the more control we can have over them. Therefore, we are motivated to oversimplify the things that we are confronted with.

- We stereotype because it enables us to boil down a very complicated set of data into some simple rule. This can be helpful and adaptive when we understand that the rule is just a schematic, or an oversimplified representation of a much more complicated reality. However, accepting our oversimplified versions of reality as reality leads to bigoted mindsets.

- We also have a desire for the universe, and our lives, to have meaning. We want there to be an overarching meaning to our existence because it gives us a sense of purpose. We want to believe that things happen for a reason, but the reality is probably closer to the fact that stuff just happens.

- Related to this is our desire to believe that big effects must have big causes. We don't like to think that there could be a massive consequence to a very innocuous or innocent cause.

- Another need that we have is the need for self-esteem—the need to not only feel good about ourselves, but to feel that the others in our community respect us. This has largely to do with the fact that we are intensely social animals.

- The need for self-esteem is often referred to as having an ego, and a certain amount of ego is very adaptive, but it also powerfully motivates us to interpret the world in a way that is favorable to our ego.

- In psychology, the **fundamental attribution error** is our tendency to look for external causes to explain our behavior. When we do this, we're very good at rationalizing our behavior in order to protect our self-esteem.

In addition to basic emotions, we also have a set of higher psychological needs, including the desire for self-actualization.

- We also act to avoid social embarrassment or stigma. For example, we may avoid appearing inconsistent. We always want to make our behavior and beliefs seem consistent to others.

- We also have a very strong resistance to admitting error. We don't like to admit that we're wrong or to admit that we have flaws because that is a threat to our self-esteem and ego.

- Much of how various motivations affect our thoughts and behavior can be explained with a theory known as **cognitive dissonance**, which is a state of mind that is caused by the act of holding two beliefs at the same time that are mutually exclusive, or that conflict with each other. We don't like the feeling of cognitive dissonance, so it motivates us to resolve the conflict.

- Initially, we may avoid cognitive dissonance through compartmentalization, in which we simply keep conflicting beliefs separate from each other, but when they are forced into conflict, we need to resolve that conflict somehow.

- An adaptive way to resolve this conflict is to update one or both beliefs, but what we tend to do instead is to rationalize the belief that we want to hold. We engage in a logical process called special pleading, in which we invent reasons to resolve the apparent conflict between different beliefs. Humans are very good at inventing reasons to justify our beliefs.

Senses That Motivate

- Our sense of justice is hardwired into our brains. It's not a learned sense; it is innate. In fact, animals also have been shown to have an innate sense of justice. For example, there is a species of birds that defends each other from predators, and they seem to have an innate sense of reciprocity, or of justice.

- Another sense that is inherent in humans is the sense of essence, or the notion that inanimate objects can carry the essence of their history. In fact, most cultures have a concept of spirituality. This innate sense of essence goes beyond inanimate objects, and we think that there is a spiritual force—whether it's called animus, chi, or prana—that separates us from things that are nonliving.

- In fact, we tend to categorize living from nonliving things in our brains, and we process information about living things differently than nonliving things. Specifically, living things are processed through the emotional centers of our brain; we imbue meaning and feeling to things that we think are alive in ways that we don't do neurologically to things that are inanimate.

- This division is not exactly between living and nonliving things. It's actually between things that we think of as having agency, which means that something acts as if it has a will of its own, and things that we think of as not having agency. This explains, for example, why we so easily imbue meaning and emotions onto cartoon characters—because they're acting as if they are people, which triggers the emotional hardwiring in our brains.

- We also have a sense of the supernatural—the belief that there is more to the world than what is immediately apparent. This ties back further to our need for a sense of connection, for there to be meaning, and for the profound. When we have a sense that we are connected to something that is profound, it feels good. This can then be reinforced by **confirmation bias**, which involves seeking out data that seems to confirm our beliefs.

Motivation, Emotion, and Behavior

- Psychologists have looked for ways to influence people's behavior. One of many practical reasons that we might want to do this is for public service campaigns.

- When it comes to influencing others' behavior, our initial instinct is to give people information, assuming that they will arrive through reason at the correct decision and behavior—but research has shown that this is not very effective.

- It's very difficult to change people's behavior by making a rational argument to them because their behavior is still overwhelmed by their beliefs and by their emotions. However, if you address the individual's emotions, that is much more effective.

- It's still difficult to get people to change old habits, but if you convince them by using social pressures, then this utilizes a technique called social norming. If you tell people, for example, that other people don't drink and drive, that will have more of an impact on their behavior than telling them the reasons why they shouldn't drink and drive.

- Children are very socially inept. Their brains have not fully developed, specifically their frontal lobes, which give us the ability to socialize—to plan our activity and to think about how our behavior will be perceived by others. Children have many of the same basic motivations and emotions that adults do, but they don't have the social filter that we have in place, so their motives

are much more transparent. Therefore, children serve as a window into human emotions and motivations.

- Adults are better at hiding emotions and motivations. We're better at rationalizing what we want to believe, and we're better at putting a socially acceptable spin on our behavior. The underlying psychological motivations, however, are largely the same for adults as for children.

- Ironically, highly intelligent people may not necessarily be better at making decisions, but they are better at rationalizing the decisions that they do make. Psychologists now recognize a separate skill set called emotional intelligence, which involves understanding the relationship between our motivations and our decisions—the tendency to relieve cognitive dissonance with rationalization.

Important Terms

cognitive dissonance: An unpleasant emotion generated by the simultaneous existence of mutually exclusive beliefs.

confirmation bias: A cognitive bias to support beliefs we already hold, including the tendency to notice and accept confirming information while ignoring or rationalizing disconfirming information.

default mode: A common behavior that results from evolved emotions and subconscious processes without metacognitive insight.

fundamental attribution error: A psychological term that refers to the tendency to ascribe the actions of others to internal motives and attributes rather than external situational factors.

hierarchy of needs: The term coined by Abraham Maslow that describes the relationship among the basic and higher human needs—from physiological needs like food to emotional needs like self-actualization.

neocortex: The neocortex is the most recently evolved portion of the human brain—specifically, the frontal lobes, which provide executive function, among other things.

subconscious: Brain processing that occurs without conscious awareness.

Suggested Reading

Gazzaniga, *The Mind's Past.*

Hood, *Supersense.*

Shermer, *The Believing Brain.*

Wiseman, *59 Seconds*.

Questions to Consider

1. How does knowledge of brain anatomy and function inform the process of our decision making?

2. Do humans have free will, or are all of our thoughts and behaviors the result of neurological destiny?

Errors of Perception

Lecture 3

In order to understand the nature of human thinking and belief, it is necessary to understand how our brains acquire and process information. This lecture will begin this section on exploring the ways in which our underlying brain activity is deceptive and constructed by examining the nature of perception and all the ways in which humans can be deceived by what we think we perceive and by what we miss. This lecture will cover phenomena such as attentional blindness, change blindness, and optical illusions.

Deceiving the Brain

- You cannot trust anything you think you see or perceive. There are simply too many flaws in the ways our brain constructs these perceptions.

- Our perceptions are not passive. In fact, our brains actively construct a picture of what is going on around us based on a tiny fraction of all the sensory information that's coming in, which introduces many opportunities for distortions and error.

- Over centuries, magicians have learned how to exploit the foibles of the brain's sensory processing. They have developed a practical knowledge of how to do things right in front of your face without you seeing or perceiving that these things occurred. They use this knowledge for entertainment, but it is possible for these same tricks to be used for nefarious purposes.

- Artists have also learned how to exploit the ways in which our brain processes information in order to create specific effects. For example, they have developed laws of perspective and dimensionality, resulting in the ability to create a three-dimensional image on a two-dimensional canvas.

Optical Illusions

- Perhaps the simplest demonstration of the constructed aspect of our sensory input is **optical illusions**. By definition, all types of illusions occur when the brain constructs sensory perception in an incorrect way, causing a misperception of reality.

- Generally, objects in our world appear to be stable and accurate with respect to reality. Psychologists refer to this property as **constancy**.

- Optical illusions, by definition, represent an exception to constancy—a time when objects either are not stable or do not accord with reality. This is because the brain has to make assumptions about what's likely to be true, and then it processes the sensory information based on those assumptions. Most of the time, those assumptions are correct; when they're not correct, that results in an optical illusion.

- Constructed optical illusions are designed to specifically exploit known ways in which the brain processes information. There are different types of optical illusions, including perspective illusions, which exploit the ways in which our brains can construct three-dimensional images out of two-dimensional input.

- There are optical illusions that are based on the relative shade and size of objects. There are also illusions that are based on ambiguous stimuli, in which the brain can construct an image in more than one way and switches back and forth between different constructions.

- Additionally, there are afterimage optical illusions that the visual system will adapt to lighting and color, for example, and then when those are changed, the adaptation causes an afterimage that's not really there.

- Other three-dimensional illusions that the brain makes assumptions about are size, distance, and relative position. These assumptions are based on what is usually correct, but when one or more of those

assumptions are incorrect, the brain can construct a false three-dimensional image of reality.

- There are also perceptual reversals, which have to do with ambiguous stimuli and your brain constructing images in different ways at different times. There is the classic cube illusion, for example, in which there is a two-dimensional drawing of a three-dimensional cube and either face can be perceived as pointing toward you.

Seeing What's Not There

- Nobody is immune to optical illusions, so even being a trained pilot or observer does not make your brain construct things differently.

- For example, in Stephenville, Texas, on January 8, 2008, witnesses saw a UFO, which stands for unidentified flying object, that they reported was one mile long. Investigations revealed, however, that what they were seeing were actually flares and that the witnesses constructed the UFO by connecting the dots of light.

- When our brain is constructing our perception of the world around us, it will fill in lines or connections where it thinks they should be based on assumptions about what it thinks it's seeing.

- Another example is the air raid over Los Angeles, California, that took place on February 25, 1942, during which over 1,400 antiaircraft shells were fired. Eventually, it was concluded that the air raid might have been triggered by something as innocuous as a weather balloon. Because it was the beginning of World War II, soldiers that were firing these shells thought they were seeing planes invading the United States.

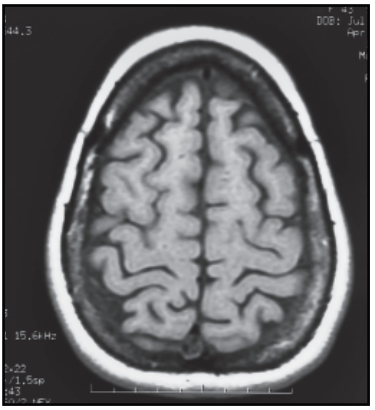
- Another dramatic example of how our brain constructs a picture in our heads from available sensory input is the fact that the different senses can actually influence each other. Our brains will compare different types of sensory input in order to construct one seamless

picture, and it will adjust one sense or the other in order to make things match.

- Gender perception is also a combination of different types of sensory input. There are numerous studies that indicate that what we see in terms of gender is affected by the voice that we hear, especially when the visual input is ambiguous or androgynous.

- This same research also shows that we respond better to congruous sensory input rather than incongruous input when the voice matches the face we see the sound coming from and the movements that are being made. Sometimes our brain will have difficulty putting conflicting sensory input together.

- Another example of how our brain uses different types of sensory input in order to construct its picture is the **McGurk effect**, which describes the fact that the consonants we hear are affected by the mouth movements we see. In other words, our brain adjusts the sound in order to make it congruous with the lip movements that you see, so you hear different consonants.



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There are many flaws in the ways our brains construct what we think we see or perceive.

- There is also temporal synchronization. Activities that combine sounds and sights, such as clapping hands, seem to be simultaneous, but the light traveling from someone clapping his or her hands travels much faster than the sound waves propagate. Therefore, the two sensory inputs do not arrive at your sensory organs at exactly the same time. It also takes slightly different amounts of time for your brain to process those two types of information.

- However, when we look at someone clapping his or her hands, the two events appear to be simultaneous. This is a constructed illusion in your brain, which synchronizes the two events because it knows that they're supposed to occur at the same time. In fact, as long as the visual and auditory information are within 80 milliseconds of each other, your brain will perceive them as being simultaneous.

- **Synesthesia** is a pathological phenomenon, which means that it occurs in some people but not in others. Synesthesia occurs when one sensory modality is interpreted by the brain as if it were a different sensory modality. Therefore, people with synesthesia may see numbers, hear light, or smell colors. It's not clear whether synesthesia represents a bleeding over of information from one sensory area to an adjacent sensory area in the brain or if this is an alternate type of wiring in the brain.

Paying Attention to Sensory Information

- Attention is immensely important to the notion of perception because we are constantly bombarded with an overwhelming amount of sensory information, and we cannot possibly pay attention to even a significant fraction of it—let alone all of it—at the same time. We filter out most sensory information that reaches us and pay attention to only what our brains deem to be important.

- In some experiments of attention, subjects watch a video and are instructed to focus on one type of activity that's occurring in the video while at the same time, something else very dramatic is happening in the video. About 60 percent of people who watch the video will be completely unaware of dramatic events occurring right before their eyes simply because they were instructed to attend to a different part of the video.

- The amount of focus that we have can shift around. We can be focused on just one part of our visual field, completely ignoring the peripheral vision, or we can be on the lookout, trying to diffuse our attention among a greater percentage of our visual field.

- We tend to shift around to different parts of our peripheral vision at different times, and when we do, the objects in that part of the visual field are enhanced. Your brain will process more of the information coming from that part of the visual field and will suppress information coming from other parts of the visual field in order to prevent getting distracted by what it deems to be irrelevant information. **Inattentional blindness** describes the notion that we are blind to things that we are not attending to.

- With a closely related phenomenon called **change blindness**, we do not notice sometimes even dramatic changes to our environment. For example, several experiments show that when interacting with an unfamiliar person, the person can change outside of your view and about 60 percent of the time subjects won't notice that they're talking to an entirely different person than they were before the swap.

- An example of our ability to only attend to a small number of things at the same time is **multitasking**. The term multitasking is used to define doing more than one thing at the same time, but research shows that people essentially cannot attend to more than one thing at the same time.

- In some experiments, it's been demonstrated that people who think that they are good at multitasking actually suffer from multitasking the most; their performance decreased the greatest when they attempted to multitask.

- Eyewitness testimony is notoriously unreliable. Eyewitnesses are subject to suggestion; they have a false confidence in their own accuracy and are subject to **confabulation**, or making up details. Our brains construct a consistent reality out of what it thinks it perceives that involves subconsciously filling in missing pieces.

- Perception is a construct—it is something that is happening inside your brain. Each individual sensory stream is interpreted and modified: The different streams are combined, compared, and

then altered based on that comparison. We attend to a very small subset of that information, which we weave into a complete story by adding confabulating pieces as needed. The end result is a story that is largely fiction.

- Sensory input is constructed into meaningful patterns. Not only are the components of what we perceive constructed, but also how we put our perceptions together into a meaningful way is also constructed. This will often result in unnecessary arguments from an irrational faith in the fidelity of our perceptions. If, however, we understand the limits of our perceptions, then we will not overly rely upon them.

Important Terms

change blindness: The experimentally verified tendency of humans not to notice changes in their environment.

confabulation: The filling in of details missing from either perception or memory. The brain invents the missing details to construct a consistent narrative.

constancy: The fact that our brains construct a constant and consistent model of what we perceive that generally matches reality.

inattentional blindness: This phenomenon refers to the lack of attention to sensory information, especially while attending to other sensory input. Significant information right before our eyes can be completely missed and is simply not processed.

McGurk effect: The phenomenon that the consonant sounds we hear are affected by the lip movements we see.

multitasking: Dividing attention between two or more tasks or sensory inputs.

optical illusion: The common term for the failure of constancy, or a breakdown in the process of creating a constant and consistent view of reality. Illusions occur when what our brain constructs does not match reality or when there is an inherent contradiction or ambiguity in the way perceptual information is constructed.

synesthesia: When more than one sensory modality is combined or when one sensory modality is interpreted as another, such as smelling colors.

Suggested Reading

Fineman, "Sightings, UFOs, and Visual Perception."

Macknik, Martinez-Conde, and Blakeslee, *Sleights of Mind.*

Novella, "The Spinning Girl Illusion Revisited."

Seckel, *The Great Book of Optical Illusions*.

Questions to Consider

1. How does the brain process sensory information, and how does this affect what we think we perceive?

2. What are the various factors that make eyewitness testimony unreliable?

Flaws and Fabrications of Memory

Lecture 4

There are numerous ways in which human memory is flawed. Far from being a passive recording of events, memory is constructed, filtered through our beliefs, and subjected to contamination and morphing over time. Memories can even be fused or entirely fabricated. It's naive to implicitly trust our memories, and it's important to recognize that we need to be realistic and humble about the limitations and flaws of human memory. Without external, objective verification, we can't know how accurate the details of our memories are. Recognizing the fallibility of human memory is an important step toward true critical thinking.

Human Memory

- Human memory is utterly flawed. Like perceptions, memory is not a passive recording; instead, our memories are constructed entirely by our brains. In fact, they're tied together with everything that we think and believe with our internal model of reality.

- There are various different types of memory. **Short-term memory** is a several-minute window of memory that is stored in the hippocampus of the brain. **Working memory** is our ability to hold a few bits of information in our minds and manipulate it in some way. **Long-term memory** is stored more diffusely throughout the brain for a long period of time.

- Human memory can be incredibly powerful in terms of raw capacity and being familiar with objects that we have seen, especially in terms of visual memory, but there are many ways in which it is limited.

Limitations of Human Memory

- There is a false assumption that all problems with memory are associated with **recall**. Some memories never form; in other words, we may experience something but never consolidate it from short-

term into long-term memory. Memories also degrade, fuse, and morph over time.

- A **flashbulb memory** is a type of long-term memory that we have for an unexpected emotional event—as opposed to everyday, mundane events of our lives. Flashbulb memories tend to be vivid, long-lasting memories, and they are reinforced by the emotion of the event. In fact, a strong emotional experience, such as a traumatic event, strongly reinforces a memory.

- Jennifer Talarico and David Rubin did a flashbulb memory recall study about the September 11, 2001, terrorist attacks and found that the accuracy and consistency of everyday and flashbulb memories degrade equally over time. Additionally, for everyday memories, subjects' confidence also decreased at about the same rate as their accuracy did, but for flashbulb memories, their confidence remained high and the memories remained vivid and emotional.

- Interestingly, confidence in a memory is not a good predictor of the accuracy of a memory. We tend to naively assume that if we are very confident in a memory—if it feels vivid to us and if it can be easily recalled—it must therefore be accurate, but the research does not support this.

- It's still not certain whether the way we assess our confidence in our memories and the way we form those memories are the same process or if there's a distinct neurological process somewhere else in the brain where we assess our confidence in our memories.

- Memories of details tend to increase confidence, but having a vivid memory for detail does not necessarily predict accuracy. Overall, familiarity does not increase confidence much, but it is found to be better correlated with accuracy in some experiments.

- **Source amnesia** is an example of the disconnect between accuracy and confidence. We have a particularly bad memory for the source of information, even when we can recall the information itself;

our brains simply do not dedicate many memory resources to source information.

- In our complicated civilization, we often have to assess the reliability of multiple sources of information in order to note something meaningful about the information, so source amnesia is a major problem in our society.

- Similarly, truth amnesia involves remembering a claim much more easily than remembering the distinct fact of whether that claim is a myth. In 2007, a study conducted by Ian Skurnik and his collaborators showed that as many as 27 percent of young adults misremembered a false statement as being true only three days after they were told, and 40 percent of older adults misremembered a false statement as being true. They remembered that they had heard the statement before, but they didn't remember that it was false.

- Truth status appears to fade faster than familiarity, as does source status. Therefore, familiarity leads to a truth bias, which gets reinforced with repetition. The effect of not remembering the truth status of a claim is worsened when the truth status is not revealed until the end. This has many implications for information campaigns that involve myth busting.

- Psychologists also distinguish between thematic and detail memory, which are different types of memory that we have for an event. Thematic memory is responsible for the overall emotional content of an event; detail memory is responsible for the details of an event.

- There are different brain patterns for each of these types of memory. **Functional magnetic resonance imaging (fMRI)**, which is a way of imaging real-time brain activity, shows that different parts of the brain activate during thematic versus detail memory tasks. In other words, remembering details is neurologically different than remembering the theme of a memory.

- We also tend to focus on stimuli and ignore peripheral details. For example, witnesses will tend to remember a weapon that an alleged assailant was holding; they tend to focus on emotionally laden detail. However, when the police ask them to remember such details as eye color and clothing, they may not remember those kinds of details at all.

Memory contamination occurs when details that are introduced after an event are incorporated into the memory of the event itself.

Altering Memory Details

- What's much worse than not having a good memory for details is the fact that we actually alter the details. We construct a narrative, which has emotions and themes attached to it, and we alter details in order to be in line with our thematic narrative. Therefore, details are also biased thematically.

- In this way, past events become contaminated; memory contamination occurs when we incorporate details that we are exposed to after an event into the memory of the event itself.

- Researcher Elizabeth Loftus and her collaborators found that people incorporate misleading details from questions or other accounts into their own visual memory. These are false memories that are constructed by someone asking a leading question, such as, "How fast were you going when you slammed into that car?"—implying that you were speeding.

- There is also a need to conform to what we think we know about the event we're trying to recall. Witnesses, therefore, tend to contaminate each other's accounts, bringing them in line with each other. This is not deliberate deception on the part of the witnesses; our brains fill in gaps in our narratives, glossing over any inconsistencies.

- Additionally, we tend to invent details to fill in the gaps in order to create a consistent story and reinforce the emotional themes. This relates to the fact that memory is a construction—not a passive recording.

- For example, when we blink, we miss a tiny bit of visual information, and our brains stitch together the visual information so that we have one continuous stream. We do this cognitively as well; we stitch together different bits of things we perceive about an event in the process of confabulation.

- Forced confabulation occurs when leading questions are asked about a film that was viewed, for example. In studies of forced confabulation, subjects can remember seeing a nonexistent scene that they were asked about. A memory of an event we confabulate feels like a memory of something we actually experienced, and we don't have a way of telling the difference.

- This is sometimes referred to as the Rashomon effect, which is based on a 1950 Akira Kurosawa film about a rape and murder in which the same story was told from four different accounts, and it was a very artistic depiction of how different accounts of the same event can be. Everyone has their own perspective, filter, and memory, and therefore, when they compare stories after the event, there may be striking differences in how each person constructs the same event that they all experienced at the same time.

Inventing False Memories and Experiences

- The ability to confabulate can lead to what are called false memories. In 1988, Ellen Bass and Laura Davis wrote a book called

The Courage to Heal, in which they promoted the idea that many people, mostly women, were abused as children, and they felt that the memories of these highly traumatic events were repressed and later manifested as adults as anxiety, depression, eating disorders, and other problems.

- Bass and Davis created an epidemic of what is now known as **false memory syndrome**. Therapists who followed their prescription encouraged clients to remember details of abuse, which led to many thousands of people manufacturing memories of intense abuse as children and believing that they were real. In fact, there are cases of people who were sentenced to prison for committing abuses when the only evidence against them was from false memories.

- It's so easy to create false memories that you could do so by giving people a simple word list and having them memorize it. You can give them very subtle suggestions by having a theme to the words and then by showing them another list that included words that were not, in fact, on the first list but are similar or on the same theme. They will construct a false memory of seeing those words because they fit with the theme of the words that they were given.

- There are often social demands and other motivational factors that may cause us to bring our memories in line with what's being suggested to us. Children are particularly susceptible to suggestibility and creating false memory.

- In addition to false memories, false experiences are very easy to generate. In one study, participants read an advertisement for a new but false brand of popcorn that vividly described both the taste and feel of the popcorn. A week later, participants were asked whether they were actually given the popcorn to taste or whether it was just described to them, and a certain percentage of the people who were never exposed to the popcorn remembered having eaten it. In other words, they inserted themselves into the memory of an event they only read about.

- This is a caution for any profession that must solicit a history from another person, such as police officers, physicians, and therapists. People in these professions need to remember the incredible tendency for suggestibility and creating false memories.

- Furthermore, not only do we need to avoid encouraging people to invent memories, but we also need to make sure there's always some external, objective verification. Courts, in fact, have been using more caution about the validity of eyewitness testimony and recognition of the needs to validate any testimony with some kind of objective evidence.

Important Terms

false memory syndrome: The implantation of false memories that are thought to be real by the possessor of the memory, often resulting from strong suggestion, imagining, or hypnosis.

flashbulb memory: A detailed memory or snapshot of a sudden, unexpected, and emotionally significant event.

functional magnetic resonance imaging (fMRI): Application of magnetic resonance imaging, a type of medical scanner, that can be used to image the degree to which different parts of the brain are active.

long-term memory: Memories that have been consolidated into long-term storage.

recall: The act of bringing to the conscious mind memories stored in long-term memory.

short-term memory: Memory for immediate sensory or internal information that lasts from seconds to a few minutes.

source amnesia: The tendency to forget the source of information more easily than the information itself.

working memory: A type of memory that is distinct from short-term memory because it consists of information that the brain can manipulate, such as performing mental calculations.

Suggested Reading

Neimark, "It's Magical, It's Malleable, It's ... Memory."

Novella, "A Neurological Approach to Skepticism."

———, "Memory."

Shreve, *The Fallibility of Memory in Eyewitness Testimony.*

Winograd and Neisser, eds, *Affect and Accuracy in Recall*.

Questions to Consider

1. What are the various processes that occur to long-term memories that may alter their content?

2. What are the implications for investigatory professions of the extreme fallibility of human memory?

Pattern Recognition—Seeing What's Not There

Lecture 5

Humans have a well-documented tendency for pattern recognition. It is both a great cognitive strength but also can be a weakness because we may see patterns that do not actually exist. We constantly recognize illusory patterns, which are manifested in pareidolia, data mining, hyperactive agency detection, and superstitious thinking. Additionally, we have a sense of what we think is real. Critical thinking skills are a way of sifting through all of the randomness—transcending above our evolved tendency to detect patterns and agency too often—to sort out what's actually real from what only appears to be real.

Finding Meaning in Patterns

- Humans are so good at seeing patterns that we sometimes see patterns that are not even there. Brain processing is based largely on **pattern recognition**—probably because our brains are massive parallel processers with many connecting neural networks. One of our strengths as cognitive beings is making connections between different ideas, visual patterns, words, events, and objects.

- Our brains are able to process representative and abstract thinking, such as metaphors. Art is a good example of this human talent for making abstract connections, or thinking creatively.

- Additionally, we imbue meaning and emotion into the abstract patterns that we see, which makes the patterns seem real and meaningful. In fact, our brains are wired to assign meaning and emotions to things.

- Pattern recognition is filtered through a different module of the brain that undertakes what is called **reality testing**. We see many apparent patterns in the world around us, and then we run those patterns through a reality-testing algorithm to decide whether it agrees with our internal model of reality.

- Interestingly, while we're dreaming, the reality-testing module is not as active as when we are fully awake. This is why bizarre things can happen in our dreams that our dreaming selves accept and why upon awakening and remembering dreams, they no longer make sense.

- A pathological condition known as **psychosis** is essentially a lack of reality testing—a decreased ability to test the patterns that we see against reality. Psychosis makes the patterns that are seen, even the most bizarre ones, seem far more real and compelling than they actually are.

Visual Pareidolia

- There is a phenomenon known as visual pareidolia, which is a tendency to see a pattern in randomness. The most familiar example of this is seeing faces, animals, or common objects in the random shapes of clouds. We recognize that these patterns are completely random, but they still look familiar to us.

- Visual pareidolia is the most obvious example of the more general phenomenon of **pareidolia**, in which the brain seeks patterns to fit the stimuli. As our brain is constructing what we think we see and remember, it's also trying to make a pattern fit to patterns it's already familiar with. It's also interesting that once you see a pattern in random stimuli, it's very difficult, or even impossible, to not see it.

- Many so-called ghost photographs are based on pareidolia. For example, you may be taking a picture of a wispy cloud or bouncing a flash off of some dust in the room that results in an overexposed, cloudy image on the film; our brains are very good at looking at the randomness of that cloudy photograph and seeing a face or the outline of a person.

- The human face is the most familiar pattern that we will tend to impose—perhaps because a large portion of our visual cortex is dedicated to seeing faces. It's obviously important to us as social creatures to be able to recognize individuals very easily and very quickly.

An example of visual pareidolia is seeing faces, animals, or common objects in the random shapes of clouds.

- From the earliest age that we can detect it, there seems to be an inborn preference for looking at the human face. This preference for the pattern of the human face results in pareidolia that frequently results in a face.

- For example, low-resolution pictures taken by NASA probes showed a particular formation on the surface of Mars that vaguely resembled a human face, especially when it was suggested to someone. Subsequent high-resolution pictures of the same area showed a normal geological formation.

- There is a lot of hardwiring in our brain that is dedicated to inferring emotion from minimalist visual cues. We understand, for example, the emotion that a stick figure or cartoon character is supposed to have; we can personify animals and cartoon characters and imbue them with the full range of human emotions.

- When asked to tell what emotion a picture of a person is displaying, people in eastern cultures spend more time looking at the eyes whereas westerners spend more time looking at the mouth. This is reflected in emoticons, which are electronic expressions comprised of keyboard characters that resemble faces, in which western emoticons tend to vary the mouth shape whereas eastern emoticons tend to vary the eyes in order to alter the emotion that is being represented.

Audio Pareidolia

- In addition to visual pareidolia, the tendency to see patterns in audio stimuli is called audio pareidolia. The brain has a limited number of phonemes, which are components of spoken speech, that it can distinguish. We mostly learn these by age four; after which, we tend to sort anything that we are trying to understand as speech into one of our learned phonemes.

- Audio pareidolia is partially responsible for accents. People who learn one language may not be sensitive to phonemes that are not present in their language but are present in a different language, and therefore, they won't be able to make the proper distinctions when speaking that other language, which will give them a recognizable accent.

- Believers in a phenomenon called **electronic voice phenomenon (EVP)**, think that they are able to tap into the spirit world by listening to essentially static on tape recordings. They often visit an alleged haunted location and listen through recorded noise for words to pop out.

- Essentially, this is a form of **data mining**, which involves analyzing large amounts of data and looking for random patterns that occur by chance. Believers in EVP make the false assumption that a phrase they hear is real and that some spirit or ghost is actually saying those words. Psychologically, it has been demonstrated that your brain is imposing those words onto a random pattern of noise.

- A similar phenomenon is backward masking on music, or listening for secret messages in music that is played backward. After this phenomenon became popular, some musicians deliberately put backward messages in their music, but most of the time, it was random noise in the backward music that the brain fit to a familiar audio pattern.

- It has been demonstrated experimentally that we also tend to be highly suggestible in this regard. For example, it's easier to hear what you're supposed to hear after you are told that that's what you're supposed to hear. Your brain will make the connection and fit your perception to the words.

Data Mining and Hyperactive Agency Detection

- Data mining is a legitimate exercise for generating hypotheses. When scientists have large amounts of data, they may mine the data using computer models or other algorithms to look for any apparent patterns.

- The problem that occurs is when scientists assume that the patterns they see are a way of confirming an idea rather than a way of generating a hypothesis. After finding patterns, scientists need to confirm that the patterns are real by testing them against an independent set of data because if the pattern was initially there by random chance, they're going to propagate that random chance into future analyses unless they use new data.

- It is most dangerous when data mining is subconscious rather than deliberate. Because people only tend to see the pattern, they don't see all the data that the pattern is buried in.

- For example, astrological researchers look for any pattern in the data related to an astrological sign, but what they don't realize is that they are looking for any possible match—any outcome to any astrological sign. By odds alone, there's going to be randomness in the data and some patterns that emerge.

- When astrological researchers use a completely independent set of data, there is no consistent pattern with astrological signs. Astrology is based almost entirely on this false pattern recognition and data mining.

- A phenomenon called **hyperactive agency detection** describes the tendency to assume agency even when randomness is sufficient. We tend to err on the side of feeling as if there's agency even when there isn't.

- Evolutionary explanations might suggest that we evolved from ancestors who had hyperactive agency detection—who assumed that a rustling in the bushes was a predator versus just the wind—because it was a survival strategy. We didn't evolve from those who investigated which option it actually was.

- Hyperactive agency detection is reflected in our neuroanatomy and in the way that we process visual information. Our brains do not decide whether something is alive and then assign emotion to things that are alive; instead, they decide whether something is acting as if it has agency and then assign emotional meaning to it as if it's an agent. This is how we see agency in nonliving things, such as cartoon characters.

- In addition to hyperactive agency, we have a tendency to detect the essence of various things, which make them what they are. For example, psychological research has found that how a child feels about a toy will depend on whether they imbue that toy with essence. For most toys, children understand that they're just things and will happily accept an exact duplicate of them. However, if a child has a favorite toy, then he or she thinks there's something essential about that toy that would be missing if they were given an exact replica of the toy.

- Evolutionarily, it makes sense that, for example, a parent would not accept an apparent exact replica or duplicate of their child; instead, they would want to have their own child. Therefore, there seems

to be an adaptive advantage to having this sense of individuality and essence.

- Problems can arise when we see agency where it does not exist. For example, we may see an invisible hand that is controlling events, which leads to conspiracy thinking. When we see a pattern of events that we think can't be a coincidence, then we further assume that there must be an agent behind that pattern—some organization, power, magical agent, or force of nature that is making things happen the way they are.

- We need to filter our tendencies for hyperactive pattern recognition and agency detection through our reality-testing filter, but we also need to understand that pattern recognition, agency detection, belief in essence, and data mining conspire together to create the powerful illusion that we are seeing something real in the world when it's just randomness. Emotionally, an illusion might be very compelling, but we need to use critical thinking skills to systematically test apparent patterns to truly know if an illusion is real or not.

Important Terms

data mining: The process of sifting through large sets of data and looking for apparent patterns. This is a legitimate way to generate hypotheses—but not of confirming them—because this process lends itself to finding illusory patterns.

electronic voice phenomenon (EVP): The phenomenon of apparent words or phrases being found in audio recordings of allegedly haunted locations. Believers ascribe EVP to ghost phenomena, but they are more easily explained as audio pareidolia.

hyperactive agency detection: The human tendency to detect a conscious agent behind natural or random behavior or events—for example, believing that random events are a conspiracy to punish us.

pareidolia: The tendency to see patterns in random noise—for example, seeing a human face in the random features of a cloud.

pattern recognition: The phenomenon of perceiving patterns—whether in visual information, other sensory information, or even events or behavior. Humans generally have a great ability to recognize patterns and a tendency to see patterns even when they are illusory.

psychosis: A psychiatric condition characterized by impaired reality testing.

reality testing: A cognitive process by which the brain compares any new information to its internal model of reality to see if the new information makes sense.

Suggested Reading

Ariely, *Predictably Irrational, Revised and Expanded Edition.*

Blackmore, *Consciousness.*

Kahneman, *Thinking, Fast and Slow*.

Novella, "Body Snatchers, Phantom Limbs, and Alien Hands."

Questions to Consider

1. How much of what we think and feel derives from subconscious, evolved brain processing—of which we are not consciously aware?

2. How is our experience of reality a constructed process of the brain?

Our Constructed Reality

Lecture 6

The goal of this first section of the course is to give you an appreciation for the extent to which what we perceive of as reality is actually an illusion constructed by our brains. In previous lectures, you learned how perception is not only highly filtered but also constructed. Our brains assign patterns to what we perceive and then assign meaning to those patterns; our very sense of self and what we perceive of as reality is also a constructed illusion by our brains.

Brain Function

- Perhaps the most persistent illusion that is constructed by our brain is that we are one cohesive consciousness. The reality is that various regions of our brain are communicating with each other and are in frequent conflict as they each undergo their purpose.

- The neocortex, or the frontal part of our brain, has **executive function** whereas more primitive parts of the brain are the seats of emotion and instinct. The neocortex is involved with social behavior, long-term planning, and inhibition.

- Often, rather than imposing these functions on our more primitive desires, the neocortex may rationalize decisions that are made by more primitive regions. These two brain regions come into conflict, and once the conflict is resolved, our brains give us a small amount of dopamine, the reward neurotransmitter, to make us feel good.

- To investigate brain function, we use functional magnetic resonance imaging (fMRI), which scans the brain using a magnetic resonance imager to not only look at the brain, but to also see how the brain is functioning in real time. Additionally, **transcranial magnetic stimulation (TMS)** is a technique for either increasing or decreasing different regions or circuits within the brain. This

way, we can tell what they contribute to the overall functioning of the brain.

- In some cases, modern neuroscience researchers are finding the neurological correlates to what psychologists have been demonstrating for decades: different brain regions in conflict.

- Our decisions seem to be conscious, but they are often made subconsciously by an evolutionary neurobiological calculus that we are not aware of.

- In addition to decision making, **intuition** is a form of subconscious processing. For example, emotional processing, social cues, and the monitoring of our internal state are largely subconscious processes.

- Emotions are involuntary and subconscious. We don't choose to feel angry; we just feel angry and then invent a reason to explain why we feel angry—with varying degrees of insight. In addition, explanations we invent for our feelings and behavior are typically highly self-serving.

- Subconscious processing also extends to other types of processing, such as searching for a particular memory or even problem solving. For example, your brain continues to try to search your memories for the location of your car keys, even though you aren't consciously paying attention to it, and then when the match is made, the information pops into your conscious awareness.

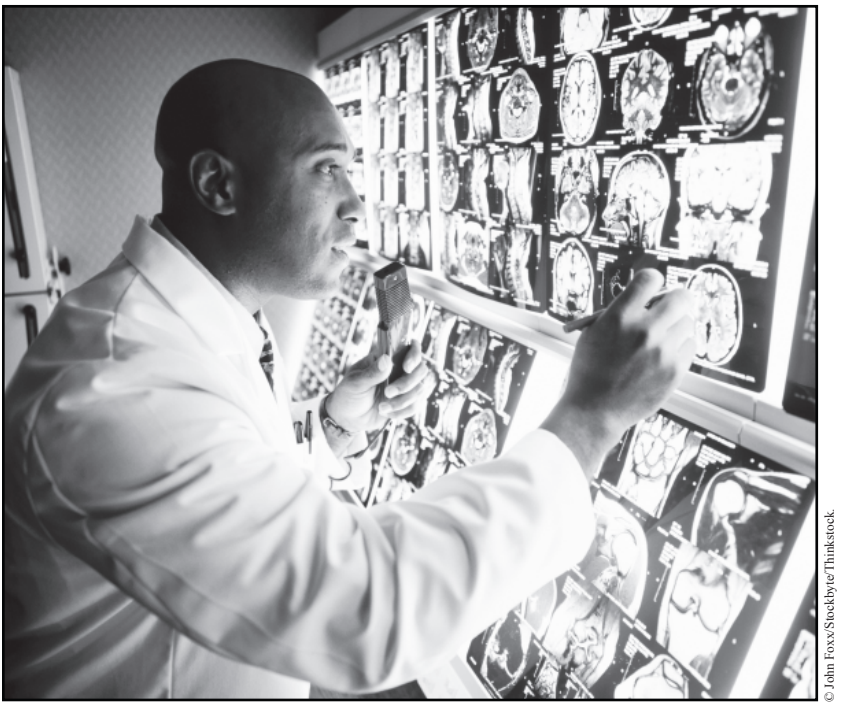
- The **global workspace** model of consciousness states that while various brain regions act like they are each their own consciousness, they all report to some central, broadly distributed network within the brain called the global workspace.

- However, recent evidence argues against the existence of a global workspace; there appears to be no central location that the various regions report to. Consciousness, therefore, is the aggregate behavior of all of these various components acting together.

Brain Research

- Research shows that we could be conscious of visual perception without the visual cortex having to report that information to any other part of the brain. In addition, decisions can be altered by altering the function of different specific brain regions.

- For example, researchers have inhibited the right temporal parietal junction using TMS. That part of the brain is involved with the **theory of mind**, which is the ability to think about the intentions of other people. When that part of the brain was inhibited, it impaired the ability of subjects to make moral judgments that specifically require a theory of mind in the calculus.



Various regions of the brain communicate with each other and frequently conflict as each region undergoes its purpose.

- A study showed that patients with damage to their insular cortex, which is often responsible for translating physical sensations into emotions, lost cravings, or the emotional desire to engage in drug seeking, based on their physical withdrawal symptoms—even in cases of lifetime smokers.

- A **split-brain experiment** is a classic type of neuroscience experiment that demonstrates the manner in which different parts of the brain construct our aggregate consciousness. Such experiments were first done by Roger Sperry and Ronald Meyers in the late 1950s and then were reproduced later by many other researchers.

- Split-brain research involves patients who have had the right and left hemispheres of their brain separated surgically to prevent seizures from spreading from one part of the brain to another and to decrease the number and severity of seizures. Because about 90 percent of the communication between the two halves of their brain is separated, these patients provide an opportunity to test the aggregate consciousness of one hemisphere separate from the aggregate consciousness of the other hemisphere.

- The right hemisphere in most people is the nondominant hemisphere and the one that is not engaged in language. The left hemisphere has the ability to speak and understand language.

- Because the two hemispheres of the brain are separated in epilepsy patients, researchers are able to show only the right hemisphere of the brain an object and then see how the individual responded to that information.

- In a classic experiment, the experimenters showed the subject's right hemisphere a bottle of soda, and then they immediately showed the subject a series of objects, one of which was the bottle of soda. When asked to choose one of the objects, the subject would pick the bottle of soda, but they wouldn't know why.

- We feel as though we are a self-contained entity that is separate from the rest of the universe. When brain regions that are involved in this feeling of separateness are inhibited, that can give an individual a powerful sense of being one with the universe, which is often interpreted as a profound spiritual experience.

- Usually, we feel as if not only do we occupy our bodies, but we exist somewhere behind the eyes. That is also a specifically constructed experience inside the brain. When these parts of the brain are inhibited by TMS, subjects have an out-of-body experience, in which they feel like they are floating somewhere above their body.

Consciousness and Motor Control

- The **ownership module** creates the sense that we own and control the different parts of our body. These networks in the brain compare sensory information that is both visual and proprioceptive and give muscle feedback to our intentions.

- If there is a disruption in this circuit by a stroke, for example, then we do not feel as if we own or control certain limbs, which will give us the sense that an arm is moving of its own will—called **alien hand syndrome**.

- This is very similar to the **phantom limb** phenomenon, in which the ownership module still owns a limb, but the limb is either dead or is even not there. Amputees often experience this; they perceive a limb that's not there.

- The perception of a **supernumerary phantom limb** is a very rare syndrome in which the ownership module still functions, but it doesn't have a limb to control, so it manufactures a virtual limb that it can control by creating the illusion of an extra arm, perhaps emerging from the middle of one's body.

- The **ideomotor effect** is essentially subconscious motor control: small motor movements that serve a purpose but that we are not fully conscious of. Probably one of the most common examples of

this is arriving at a destination and not remembering driving there; you went through all of the motor movements to drive, which can be fairly complicated, without expending any conscious effort to do so.

Altered States of Consciousness and Free Will

- We gain insight into the fact that our brain is comprised of many different regions when we experience altered states of consciousness, such as dreaming. When we are dreaming, the reality-testing part of our brain is less active, but we're still conscious. It's just a different consciousness than we're used to when we are fully awake.

- In addition, we may have experienced extreme sleep deprivation or the intoxicating effects of certain drugs. Alcohol, for example, inhibits all brain function, but especially the frontal lobes—mainly because they are a very active, energy-demanding part of the brain, so they feel the effects of alcohol more acutely than perhaps other parts of the brain do. As a result, judgment and the ability to inhibit our behavior decrease significantly.

- **Hypnosis** is another example of an altered state. In fact, when under hypnosis, we're not in a trance—it's actually a state of hyperawareness. The goal of hypnosis is to give the subject some sensory information that they're not fully conscious of; they're in a highly suggestible state, and some sensory information is being processed subconsciously.

- These various brain regions perform very complex processing, which results in our desires, motivations, and decisions. The frontal lobes are involved in decision making but also in rationalizing those decisions in order to remove cognitive dissonance, but that is also undergoing its own calculus. However, to varying degrees, we can enact upon our will—upon our frontal lobe function—or even turn off our critical thinking.

- Research has demonstrated that a very charismatic person may be able to hypnotize a crowd by turning off subjects' critical thinking, making them susceptible to suggestion in the same way that a hypnotist does.

- This brings up the tricky philosophical question of **free will**. There are people who use all of this information to question the very concept of what they call noncausal free will. Essentially, what they believe is that everything we do is deterministic. Our brains are physical, and they are just as susceptible to the laws of physics as anything else in the world. Therefore, everything that we think, believe, and do is the result of these mechanical processes in the brain—not noncausal free will.

- Research overwhelmingly shows that human beings generally have poor self-control. Generally speaking, about 95 percent of the time, people will fail to alter their own behavior through conscious effort alone to quit a bad habit, for example. It simply takes too much mental energy and vigilance.

- The brain is plastic, and habits of thought can change. Therefore, if you practice and make a concerted effort to behave in certain ways, those behaviors will become ingrained and will become easier over time.

- Practicing the habit of exhibiting executive control or executive function over your more primitive parts of the brain can be a learned skill. This is why we need and can benefit from formal reality testing, or critical thinking. We need formal logic and the methods of science to carefully and reliably sift through the myriad potential patterns that we see. This is the central concept to critical thinking.

Important Terms

alien hand syndrome: A neurological syndrome in which a person's limb, such as a hand, feels as if it is acting on its own—without conscious control. This results from damage to the brain pathways that compare the intention to move with actual movements.

executive function: A function of the frontal lobes of the brain, specifically the ability to control and plan one's behavior to meet long-term self-interest and social integration.

free will: The ability of a sentient being to make voluntary choices and decisions. Philosophers argue about whether humans have true free will or just the illusion of free will.

global workspace: A controversial theory (disputed by recent research) that posits that a distributed network in the brain is the common pathway for all conscious experience.

hypnosis: Although not a trance, hypnosis is a state of mind characterized by alertness but also by high suggestibility.

ideomotor effect: Subconscious muscle movements that conform to expectations.

intuition: Decision making or feelings, such as responses to social cues, that derive from subconscious brain processes.

ownership module: The part of the brain that creates the sensation that we own the various parts of our body.

phantom limb: An illusory limb that does not exist but that the subject can feel and even have the sense that they can move. It is commonly, but not exclusively, the result of amputation.

split-brain experiment: An experiment on a subject who had the connection between their two brain hemispheres surgically cut that helped reveal the functions of the two hemispheres and how they work together.

supernumerary phantom limb: A phantom limb that is not simply a replacement for a missing limb but is experienced in addition to the four natural limbs.

theory of mind: A psychological term that refers to the ability to understand and think about the fact that other people have their own conscious existence with their own feelings and motivations.

transcranial magnetic stimulation (TMS): Technology that uses magnetic fields to either increase or decrease activity in specific regions of the brain.

Suggested Reading

Novella, "Data Mining—Adventure in Pattern Recognition."

———, "Hyperactive Agency Detection."

———, "Pareidolia in the Brain."

Taleb, *Fooled by Randomness*.

Wiseman, *Paranormality*.

Questions to Consider

1. Humans have a heightened ability to detect patterns, but how can we know which apparent patterns are real and which are just illusions?

2. What effect does the tendency to see agency where it may not exist have on human decision making?

The Structure and Purpose of Argument

Lecture 7

The first section of this course examined how massively flawed our brains are as a tool for understanding the universe, but we do have the ability to reason. This next section of the course will address how to use that reasoning ability to override the flaws in our neurological function. This lecture will begin with a discussion of the structure and purpose of argument itself. Then, you will learn about specific logical fallacies with the goal of avoiding such fallacies in your thinking and recognizing these fallacies in the arguments of others.

Logic and Arguments

- The purpose of an **argument** for a critical thinker is not to win, although that is often the default mode of how we behave. Often, we pick a side and then defend that side at all costs, marshaling whatever arguments we think can defend that position.

- The critical thinking approach to argumentation is to value the process of developing your arguments and reaching conclusions; a critical thinker should be willing to change any conclusion when new information or a better argument is presented.

- Rationalizing is the process of starting with the conclusion and then figuring out which arguments can be marshaled in order to defend that conclusion. On the other hand, reasoning focuses on the process going forward, where the conclusion flows from the logic and not the other way around.

- Often, we use the rationalizing process, which can seem very superficially similar to reason. In fact, the point of rationalizing is to make it seem as if our decisions and conclusions are reasonable.

- When we have a conclusion that is discordant—that is not in line with the facts or is challenged by a new argument or new piece of

information—our tendency is to rationalize that new information in order to resolve the cognitive dissonance that results, and then our brains reward us for doing that.

- To avoid cognitive dissonance, we should focus on the process instead. In other words, if we don't tie ourselves firmly to a conclusion, then we won't feel any emotional dissonance when new data is encountered that shows that the conclusion is wrong.

- Specifically, in logic, the term "argument" is a set of statements used to support a conclusion. An argument must start with specific **premises** and then logically derive a conclusion from those premises. Explanations and assertions are not arguments.

- A premise is a starting point; it is a fact or assumption that we take as a given at the beginning of an argument. If a premise is false, then any argument that is based upon that premise is not **sound**. Therefore, it's very important to examine all of the premises and to recognize what the premises of an argument actually are. Often, that is a missing step in an argument.

- Assumptions can be used as premises, but we need to recognize when we are starting with a statement that is not an established fact. It is not known whether an assumption is true; it might be incomplete and might not fully capture the whole situation. Assumptions or incomplete premises weaken an argument because the argument is only as good as the premises on which it is based.

- When two or more people disagree over a factual statement, one side or both sides must be wrong in some way. By definition, two mutually exclusive conclusions can't both be correct at the same time.

- The goal should be to examine both of your arguments to find out where the assumptions are in the premises, where the false premises are, or where the errors in logic are. If you can work together to discover the errors and assumptions of logic, then you should be

able to resolve your differences and come to a better conclusion.

The goal of an argument between two people should be to uncover assumptions, false premises, and errors in logic.

Logic Jargon

- If a claim is true, it is factually correct; it is in line with reality. Arguments themselves are not true or false; their conclusions are true or false.

- In most cases, we do not have access to truth with metaphysical certitude, so what we're really looking for is something that is established to a sufficient degree that we can treat it as if it were a fact, although we know that all true statements are tentative in some way because they are dependent upon our incomplete current level of knowledge.

- If the logic works, then an argument is valid. One or more premises may still be wrong or unjustified, but an argument fails when it is impossible for the conclusion to be false if the premises are true.

- An argument is sound when all of the premises are true and the logic is valid. The conclusion of a sound argument, therefore, must be true by definition; if the premises are true, then the conclusion must also be true.

- The conclusion of an unsound or invalid argument, however, may or may not be true. Demonstrating that an argument is unsound or invalid does not prove the conclusion to be false—it just removes that argument as justification for the conclusion.

- **Deductive reasoning** uses premises to connect to a conclusion. Deduction goes from the general to the specific. You start with some general statements, and then you deduce a specific instance that must be true if those general statements are themselves true.

- For example, if premise one is that all men are mortal and premise two is that Socrates is a man, then we can arrive at the conclusion that Socrates is therefore mortal.

- Conclusions of deductive reasoning are positive assertions. They are truth statements—not value judgments, which involve subjectivity regarding what we believe. For example, there is no way to prove that Beethoven's music is better than Mozart's. Oftentimes, arguments involve one or more value judgments in the premises, and when you identify them, you can at least agree to disagree.

- In contrast to deductive reasoning, **inductive reasoning** goes from a specific observation to a general principle. Inductive reasoning is used to decide what is probably true based on observations. Science is largely based on inductive reasoning.

- For example, if premise one is that every swan that has ever been observed is white, we may come to the inductive conclusion that all swans are white. However, this statement is falsifiable; the observation of a single black swan will render the statement untrue. Then, the statement might have to be modified to the notion that most swans are white or, perhaps, that all swans except for the species of black swans are white.

Types of Logical Fallacies

- Logical fallacies are arguments in which the conclusion does not have to be true if the premises are true. The generic term for this type of invalid logic is the **non sequitur**, which literally means "it does not follow"—or the conclusion does not follow from the premises. Essentially, logical fallacies are our mechanisms for rationalizing conclusions.

- The argument from authority is a **logical fallacy** that typically suggests that a conclusion is correct because an authority figure asserts that it is correct. The more general form is that a conclusion is correct because a person or a group making the claim have some positive or admirable attribute. For example, John says it's true, and he's a nice man; therefore, his conclusion must be correct.

- We have this evolved desire to get along with the social group and to follow a leader of some sort, and we therefore have this tendency to respect celebrities, officials, experts, and professionals—people who have some claim to authority.

- The argument from authority can also be overapplied, meaning that we can dismiss legitimate arguments by the claim that they are arguments from authority. In other words, because the argument from authority is a logical fallacy, that doesn't mean that we should be dismissive of the value of the consensus of expert opinion.

- Another logical fallacy is the argument from final consequences. The form that this fallacy typically takes is that some claim cannot be true if it results in consequences that you find abhorrent; the opposite of this fallacy is that something is true because it serves a positive purpose.

- We often see this argument in conspiracy theories, for example. The logic that often goes into conspiracy theories is the principle of cui bono, or "who benefits." If an event occurs, the conspiracy theorist might ask, "Who benefited from this event?" Then, they would argue that, therefore, that person must have caused the event through some hidden conspiracy.

- A very common logical fallacy is called **post hoc ergo propter hoc**: "after which hence by which." We tend to assume that if B follows A, therefore A must have caused B.

- This logical fallacy derives from **innumeracy**, a naivety about statistics and probability. We are impressed with the pattern that B

followed A, and we instinctively don't like the explanation that the occurrence is a statistical fluke or just random chance. We like to impose meaning on the patterns that we see.

- Very similar to this is confusing correlation with causation, in which the form of the argument is not just that B follows A, but that B correlates with A. Where we see B, we also see A. The assumption, therefore, is that A must cause B. However, this is not logically the case. It's possible that B causes A. It's also possible that some other factor, C or D, causes both B and A. This also assumes that the correlation is real and not a coincidence.

- Similar to the argument from authority, the logical fallacy of assuming causation from correlation can be overapplied to dismiss the very legitimate significance of a correlation. Once we establish that a correlation is real, that doesn't mean that there's no causal relationship between the two things. It means that there are a number of possible causal relationships, one of which may be the simplest one: that A causes B.

- Another logical fallacy is special pleading, which is also called ad-hoc or post-hoc reasoning, meaning that we invent reasons as needed in order to explain certain aspects of the evidence. This logic is not formally invalid. The fallacy occurs in the process of invoking these arguments after we know that they're needed to crudely construct a problematic conclusion.

- This kind of logic may be a way of generating a hypothesis but can't be used as a premise or conclusion to dismiss inconvenient evidence or the absence of evidence that should be there.

- The special pleading fallacy is related to the fallacy of limited scope, which involves introducing a new element that is not a broadly applicable principle. It narrowly addresses a single flaw in evidence or argument.

- This type of argument has been invoked frequently to explain why there is no evidence of the existence of Bigfoot. Some have argued that perhaps he can turn invisible, travel through other dimensions, or disappear when needed to—and that's why you can never trap him.

Important Terms

argument: A statement that is used to support a conclusion or belief, often following deductive reasoning.

deductive reasoning: Reasoning that begins with one or more general statements that are taken as premises and then concludes what must be true if the premises are true.

inductive reasoning: Inductive reasoning begins with observations of the world and then derives general statements about what is probably true from those observations.

innumeracy: A lack of working knowledge of mathematics, probability, and statistics.

logical fallacy: A logical operation that is not valid.

non sequitur: A Latin term referring to an invalid argument in which the conclusion does not logically follow from the premises.

post hoc ergo propter hoc: Literally meaning "after which hence by which," a logical fallacy in which it is assumed that B is caused by A simply because B follows A.

premise: A fact that is assumed to be true, or treated as if it is true, as a starting point for an argument.

sound: In logic, this describes an argument that has both true premises and valid logic, and therefore, the conclusion must be true.

Suggested Reading

Novella, "How to Argue."

———, "Beware the Nobel Laureate Argument from Authority."

Tarski, *Introduction to Logic*.

Questions to Consider

1. What is a logical fallacy, and how can we recognize these fallacies in the arguments of others and of ourselves?

2. Are arguments based on the authority of the source of information ever valid?

Logic and Logical Fallacies

Lecture 8

The last lecture addressed the structure of argument, including the premises and the logical connection leading to a conclusion. This lecture will delve further into logical fallacies, which are sometimes used innocently but often are used as motivated reasoning to get to a desired—even if invalid—conclusion. As a critical thinker, the goal is to arrive at conclusions that are more reliable and more likely to be true by avoiding logical fallacies, using legitimate logic, and examining premises.

More Types of Logical Fallacies

- The **ad hominem** logical fallacy, or speaking "against the person," occurs when you attempt to counter the argument made by someone by focusing on the person making the argument rather than the argument itself. In a way, this is the opposite of the argument from authority.

- An example of the ad hominem argument involves rejecting scientific consensus as if it's arrogant to think that we can know anything. This is often combined with an appeal to elitism—that it is elite professionals who are making a specific claim, and therefore they can be dismissed because they're not regular people.

- A closely related logical fallacy to ad hominem is called poisoning the well, in which you're not necessarily addressing the person directly, but you're trying to taint their argument by tying it to something else that is unsavory or unpopular.

- A classic example of this is called Godwin's argument, an example of which is if Adolf Hitler believed something, it's tainted and, therefore, wrong to believe in that claim.

- This fallacy can be overapplied. Pointing out that someone who is offering you a too-good-to-be-true investment opportunity

has a prior conviction of fraud is not necessarily an attempt to poison the well of their new claims so much as to put them in a realistic perspective.

- Another logical fallacy is the tu quoque, or "you too," logical fallacy, which is an attempt to counter a legitimate criticism by pointing out that the other person is also guilty of the same thing. In other words, your claims may lack evidence, but so do the claims of these other people. Lacking evidence is lacking evidence—regardless of which claim is guilty of that failing. This frequently comes up in the promotion of unscientific or implausible medical modalities.

- A very pernicious logical fallacy, one that is very common in the promotion of **paranormal**, or supernatural, beliefs is ad ignorantiam—an appeal "to ignorance"—which involves using a lack of evidence or knowledge as if it were a positive argument for a specific conclusion.

People with paranormal beliefs often confuse the notion that something is currently unexplained with the idea that it is unexplainable.

- For example, if you cannot identify a light in the sky, by definition, it is an unidentified flying object. Therefore, it must be an alien spacecraft. What the person knows is they can't identify the object, but they then make the argument from ignorance that, therefore, it is something specific rather than simply concluding that it's unknown.

- **Intelligent design** is an argument from ignorance that is used to describe what is presented as an alternate theory to the theory of organic evolution. The notion is that life arose on this planet through the work of an intelligent agency, the intelligent designer. The arguments that are used in support of intelligent design are that we can't explain how everything evolved; therefore, the inability to explain that becomes an argument for this alternate hypothesis.

- Conspiracy theories also frequently rely on the argument from ignorance. The process of supporting a conspiracy theory often takes the form of shooting holes in the standard explanation of events and emphasizing those facts that seem anomalous or conflicting—often called **anomaly** hunting. Despite the fact that there is often a lack of positive evidence, specifically for their conspiracy theory, they're basing it entirely on the argument from ignorance—the inability to explain every detail of an event.

- Another logical fallacy is the act of confusing the notion that something is currently unexplained with the idea that it is unexplainable. This is often combined with anomaly hunting to create an argument from ignorance. It assumes that our current knowledge represents the ultimate limits of our knowledge and that because we don't currently know something, it's therefore unknowable. This is often used to support supernatural or paranormal beliefs.

- Another common logical fallacy is the **false dichotomy**, or false choice. This results from prematurely or artificially reducing the number of possible outcomes or possibilities down to just two and then making the false choice between those two. If not A, then the answer must be B, but this ignores that maybe C or D could be

the answer. Creationists often make the argument that if we didn't evolve, then we must have been created—as if that is the only other possibility.

- The false dichotomy could be a false choice between two or more possibilities that are not mutually exclusive, and it could also reduce a continuum to its extremes.

- The flip side to the false dichotomy logical fallacy is the **false continuum** fallacy, which denies the existence of extremes because there is a continuum in between. Just because there is no sharp demarcation line between tall and short, that doesn't mean that we cannot reasonably define some people as tall and other people as short.

- Another logical fallacy is inconsistency, or applying different criteria to similar situations when the same criteria really should apply. This may create mutually exclusive conclusions, or this may be a manifestation of compartmentalization, in which we apply one set of criteria to one claim and a completely distinct set of criteria to another claim that we also wish to believe, not realizing that the two are mutually exclusive. This often involves an area where value judgments are being made because it's easy to alter or tweak those value judgments in order to get to a desired conclusion.

- An example of the application of inconsistency is the kettle defense, which comes up frequently in legal trials. The name comes from the accusation that someone borrowed a neighbor's kettle and broke it, and then the person who is accused might claim simultaneously that they were never given the kettle, that it was broken from the start, and that it was in perfect condition when it was returned. All three of these claims are mutually exclusive, but if any one of them is correct, then that person is not guilty of breaking the kettle.

- Similar to inconsistency is a fallacy called moving the goal posts, which stems from changing the criteria for acceptance of a claim to keep the criteria just out of reach of whatever evidence is presented

or is currently available. This is a method for denying a claim that someone does not wish to accept or believe in.

- For example, someone might keep moving the goal post back so that no matter what evidence is presented that the United States landed on the moon, it's still not convincing enough.

- The **reductio ad absurdum** is actually a legitimate way of demonstrating that an argument is not sound by showing an absurdity to which it leads when carried to its logical conclusion. However, the logical fallacy occurs when this legitimate form of argument is abused by forcing an absurd conclusion that doesn't flow from the premises.

- For example, you don't believe in aliens or Bigfoot because you've never seen them, but you've also never personally seen the Great Wall of China, so therefore, you should be equally skeptical of the existence of the Great Wall of China.

- The slippery slope argument is similar to the false reductio ad absurdum in that it argues that if a position is accepted, then the most extreme version of that position must also be accepted or will inevitably occur. This is often used in political or persuasive arguments.

- For example, if assault rifles are banned, it will inevitably lead to banning sports or hunting weapons and to imposing further restrictions on our rights. However, it is possible to ban one type of weapon without banning all weapons or imposing further on rights.

- In formal logic, a **tautology** is a statement that must be true in all instances. The logical fallacy is the rhetorical tautology, which is the needless repetition of an idea in an argument. It becomes a fallacious form of argument when it's used to justify a conclusion. In other words, your conclusion and premise are the same, although the tautology may be disguised by stating the premise and the argument in slightly different ways.

- The **petitio principii** is the logical fallacy that is also called begging the question, which is often misused in common usage to mean that something raises the question. In logic, begging the question is assuming the conclusion in the premise. In other words, it's a form of circular reasoning.

- Another form of circular reasoning is the no true Scotsman argument, which is a semantic form of circular reasoning. For example, if someone makes the claim that all Scotsmen are brave, the counter argument might be an example of a Scotsman who is a coward. However, the original person making the claim might say, "Well, then he's no true Scotsman." This is also referred to as making a semantic argument.

- A false analogy is a form of logical fallacy that makes a point by analogy, in which the things compared are not similar in the ways that are being compared, rendering the analogy misleading or false.

- For example, the evidence for ESP, or extrasensory perception, is as statistically robust as the evidence that aspirin prevents strokes, so the argument is that, therefore, both claims should be accepted equally. However, the claim that we have ESP is not as plausible as the claim that aspirin, which has known physiological effects, decreases strokes.

- The genetic fallacy is confusingly named because we use that term now to refer to genes or inheritance, but the semantic roots simply imply the history that something has. The genetic fallacy involves assuming the historical use of something must still be relevant to the current use, even when it has changed.

- For example, the history of the word "sunrise" comes from the outdated notion that the Sun rises in the sky—as opposed to the fact that Earth rotates on its axis to cause this effect. However, when you say that the Sun rises in the morning, that doesn't mean that you are supporting a geocentric view of the universe.

- A straw man argument is extremely common and involves responding to an altered version of an opponent's argument rather than the actual position that they're taking. This is used to set up a version of the argument that is easy to knock down—a straw man.

- There is also what is called the fallacy fallacy, which involves assuming that because an argument for a conclusion is unsound, that the conclusion must be false. In fact, this is not true. Just by pointing out that an argument is fallacious doesn't mean that you can therefore arrive at the conclusion that the conclusion is false—you have to come up with other reasons.

Important Terms

ad hominem: A logical fallacy in which an assertion is said to be false or unreliable because of an alleged negative attribute of the person making the assertion; arguing against the person rather than the claim itself.

anomaly: A phenomenon that is incompatible with or cannot be explained by current scientific theories.

false continuum: A logical fallacy in which the fact that a characteristic varies along a continuum is used to argue that the extreme ends of the continuum do not exist or cannot be meaningfully identified.

false dichotomy: A logical fallacy in which multiple choices are reduced artificially to only a binary choice, or where a continuum is reduced to its two extremes.

intelligent design: The term used to self-describe a new school of creationism that holds that life is too complex to have arisen from natural processes alone.

paranormal: Any belief or phenomenon that allegedly is outside the naturalistic laws of science.

petitio principii: A Latin term for begging the question, or assuming one's conclusion in the premise of an argument.

reductio ad absurdum: A Latin term that refers to a legitimate logical argument in which a premise is taken to its logical, although absurd, conclusion. This can be a fallacious argument if the absurd conclusion is forced and does not follow inevitably from the premise.

tautology: In logical terms, this is an argument in which the conclusion simply repeats the premise and is, therefore, not a true argument.

Suggested Reading

Flew, *How to Think Straight.*

Novella, "Holmesian Deduction."

Questions to Consider

1. In what ways can the overapplication of identifying logical fallacies be a logical fallacy itself?

2. What is the proper and fallacious use of analogy in argument?

Heuristics and Cognitive Biases

Lecture 9

This lecture explores cognitive biases, the many ways in which our thinking is inclined or biased—often in very subtle or subconscious ways. An example of a cognitive bias is a heuristic, which is a mental shortcut that works most of the time but that biases thinking in specific ways that can lead to making erroneous conclusions. The worst kind of bias is the one of which you're not aware. However, when you're aware of biases, you can engage in metacognition, which loosens the grip that they have on your thinking.

Types of Heuristics

- **Cognitive biases** affect the way we argue and the way we think. Our minds will tend to take a path of least resistance unless we make a specific high-energy effort to step out of these processes and think in a more clear and logical manner.

- Cognitive biases are often related to logical fallacies: They lead us into invalid or fallacious thinking rather than into formal logical ways of thinking. These biases are numerous, pervasive, and can have a very powerful influence on how we think.

- A heuristic is a type of cognitive bias that is defined as a rule of thumb that we subconsciously apply—a mental shortcut. The conclusions that we arrive at through these heuristic methods may be correct much of the time; only a little accuracy is sacrificed for the efficiency of decision making.

- We often think of heuristics as simple common sense, but they are not strictly logically correct, which means that some of the time they can lead us to incorrect conclusions.

- You could also think of them as rules for making decisions, making judgments, or solving problems. They may be practical; the trial-

and-error approach is a common heuristic. However, in our complex modern world, heuristics of which we are not aware can lead us astray.

- Psychologists have theorized that heuristics are a way of substituting a simple computational problem for a more complex one without being aware. This could be very practical and useful—as long as we're aware that it's a first approximation of the truth and not strictly true.

- A heuristic called **anchoring** involves the tendency to focus on a prominent feature of an object, person, or event and then make decisions or judgments based on that single feature alone. This is a way of oversimplifying the complexity that we're confronted with.

- For example, the number of options that exist when buying a camera can be dizzying; therefore, advertisers typically boil it all down to megapixels, ignoring other very important features—such as the quality and size of the lens.

- One aspect of the anchoring heuristic is called anchoring and adjustment, in which the first number we encounter tends to subconsciously bias all of our later thinking on that subject.

- Anchoring is used widely in negotiation and marketing. For

Marketers often use the existence of heuristics and cognitive biases to their benefit when selling products.

example, marketers may sell products labeled as three for $19.95. This subtly encourages shoppers to buy three of the item, even though they don't have to. They could purchase one or two at the sale price, but they anchor to the three for $19.95 because that's what they were initially offered.

- The **availability heuristic** could be very subtle and powerful in its influence over our thinking. Essentially, what is immediately accessible to us—what we can think of—we assume must be important and influential. The assumption is that if we can think of an example of something, then that thing must be common or representative. It also gives weight to events that are recent, vivid, personal, and emotional.

- Medical students tend to remember their recent patients—especially recent, dramatic cases—and they shouldn't assume that what happened with that patient is representative of patients with that condition in general because it is a biased dataset.

- This is related to anecdotal evidence. Essentially, **anecdotes** are experiences that we personally have in our everyday lives that are not part of a controlled or experimental condition, but we use them as a method for estimating probability.

- For example, if we're trying to estimate how common allergies to strawberries are, we will tend to think of examples of people who have allergies to strawberries and conclude that strawberry allergies must be common. However, it could be a minor coincidence that you happen to know someone with a strawberry allergy.

- Similarly, if the media shows us stories of disasters and crimes repeatedly, we will tend to think that they are more common, even if they are showing rare events. This has huge implications for viewers watching news outlets that have particular biases.

- **Exemplars**—which are cases that represent a phenomenon and are vivid, dramatic examples—are a reflection of the availability

heuristic. Exemplars tend to have a greater influence on our judgments than statistical information about the statistical rate at which things occur.

- Exemplars also reflect our storytelling bias. We are social creatures programmed to respond to stories, especially emotional ones. This is why marketers will use a dramatic story to make a point rather than give you dry, statistical information.

- Another heuristic is the escalation of commitment. Once we have committed to a decision, we tend to stick to that commitment. We feel like we have invested in it, and therefore, that feeling biases all later judgments about that commitment. We're overly influenced by what we have already committed to, even if further commitment is a losing proposition—including money, time, or even soldiers' lives.

- The **representativeness heuristic** is the assumption that, typically, causes must resemble effects. Emotionally charged effects, for example, we assume must have emotionally charged causes. The assassination of John F. Kennedy is an example. Could it be that one deranged man acting on his own caused something so momentous? That doesn't seem right.

- The effort heuristic is similar to the escalating investment heuristic and tells us that we value items more if they require greater effort to obtain. This is an example of a mental shortcut, but it is not necessarily logically true. We may obtain something easily that happens to be highly valuable.

- For example, we will spend $100 that we earned through hard work much more carefully than we will spend $100 that we found lying on the sidewalk. This is what psychologists call the found money effect.

Types of Confirmation Biases

- A confirmation bias is one of the most pervasive biases in our thinking and is an important one to understand thoroughly. We tend to accept information and events that support our beliefs and interpret them favorably.

- For example, consider interpreting a scientific study. If the conclusion of the study is something that we agree with, we accept it as a good, solid study. If the conclusion of the study is something we disagree with, we're going to look much more carefully at potential flaws in the study to try to find some way to dismiss the conclusion. Research shows that we expend a great deal of time and effort finding reasons to rationalize the data.

- By noticing only the evidence that confirms our beliefs, we are picking out bits of data from many potential data, and that's why we systematically need to look through data in order to draw any meaningful or reliable conclusions about it.

- An example of a confirmation bias is called the toupee fallacy. Some people believe that they can always tell when a man is wearing a toupee because when they notice a man wearing a toupee, they take that as confirmation of their ability. However, they're not accounting for the fact that they don't notice when they don't recognize a toupee—that data is completely missing from their dataset.

- A **congruence bias**, a very subtle bias that can powerfully lead to confirmation bias, is the tendency to test our own theories about things but not to also test alternative theories. In order to avoid this, we need to conduct observations that are designed to test multiple hypotheses—not just our own. This tendency leads people to firmly hold conclusions that may have no statistical basis in reality.

- The **exposure effect** is a form of familiarity bias in which we tend to rate things more favorably the more familiar we are with them. That's why repetition is often used in marketing: The more you are

exposed to a brand, the more familiar you are with it, and the more likely you are to purchase it.

- A choice-supportive bias is a bias in which once we make a decision, we then assess that decision much more favorably. This is a way of relieving some of the anxiety or angst over whether we made the right decision. When we buy something, we therefore have a tendency to rate what we purchased much more favorably than we did prior to deciding that that's what we were going to purchase. In essence, we're trying to justify a decision that we already made.

- Choice-supportive biases sometimes lead to an interesting effect: We may downgrade our assessment of the second item on our list. For example, when our decision comes down to our first and second choices, and we ultimately decide to go with what became our first choice, we will justify that decision by increasing our assessment of our first choice and downgrading our assessment of the second choice.

- Experimentally, subjects are asked, "Number one is no longer available; what are you going to take as a replacement?" As a result, many skip over their second choice and take their prior third choice because they've already invested mental effort in downgrading their assessment of the second choice.

- Another very powerful bias is what psychologists call the fundamental attribution error, which is an actor-observer bias, or a tendency to explain the actions of others according to their personality traits while downplaying situational factors. However, we explain our own behavior with situational factors and downplay personality traits.

- For example, if someone trips while walking down the sidewalk, we're likely to conclude that he or she is a clumsy person. If we trip when walking down the sidewalk, however, we will blame it on an external factor, such as a crack in the sidewalk.

- Wishful thinking is another bias toward favorable ideas that are emotionally appealing to us regardless of the logic and evidence. This is also called an optimism bias. For example, this motivates people to seek highly implausible—even magical—treatments for their ailments over warnings that such treatments do not work. In this case, their desire for the treatment to work overwhelms their logic. The lottery industry is largely based on this bias.

- The **Forer effect** (also called the Barnum effect) reflects a tendency to make judgments about vague or general descriptions and interpret them as being specifically tailored for us—as when reading astrological passages. Vague statements tend to be rated much more highly accurate than more specific statements. Essentially, confirmation biases, familiarity heuristics, and availability heuristics are activated. We look for examples that support the statements that we are being told, and when we can find them, we take that as confirmation that they're accurate.

Important Terms

anchoring: The tendency to focus disproportionately on one feature or aspect of an item or phenomenon and base judgments on that one feature.

anecdote: An uncontrolled or poorly documented observation or experience.

availability heuristic: The tendency to believe that a phenomenon is more likely or more important if we can readily think of examples of the phenomenon.

cognitive bias: A subconscious tendency to think in a certain way, or a bias toward certain decision-making pathways.

congruence bias: The tendency to test our own theories but not alternative theories, which can lead to a false sense of confirmation of our own beliefs.

exemplar: A case that vividly represents a phenomenon, making it seem more likely, common, or significant.

exposure effect: The tendency to more favorably rate things or beliefs with which we are more familiar.

Forer effect: The tendency to take vague or general statements and apply them specifically to ourselves, or to find specific examples, making the statements seem more accurate and specific than they are.

representativeness heuristic: The assumption or bias to believe that causes resemble effects. Therefore, for example, a large effect must have had an equally large cause.

Suggested Reading

Evans, *Bias in Human Reasoning.*

Gilovich, *How We Know What Isn't So*.

Kida, *Don't Believe Everything You Think.*

Questions to Consider

1. How do subconscious heuristics, or common patterns of thought, often lead us astray?

2. How can confirmation bias make us feel very confident in a belief that is entirely false?

Poor at Probability—Our Innate Innumeracy

Lecture 10

Knowledge of mathematics and probability are critical for making sense of the world, and while human brains excel at pattern recognition, understanding numbers and statistics can be very counterintuitive. This lecture will cover our inherent sense of numbers, the law of large numbers, and the nature of anecdote. Examples of the effect of innumeracy include the power of cold reading and retrofitting evidence. The solution to our innumeracy is metacognition—understanding the flaws in our natural cognitive tendencies—and substituting formal, mathematical analysis for our naive senses.

Numbers and Coincidence

- Humans are terrible at probability. Our brains are very good at certain tasks, such as pattern recognition, but we have a horrible innate sense of probability. We especially have difficulty dealing with large numbers. We appear to have evolved an intuitive sense of small numbers but can only deal with large numbers in the abstract language of mathematics.

- This innumeracy, or failure to appreciate the statistical power of geometric progressions, leads to a number of probability-based cognitive biases. For example, we tend to notice coincidence, when two events seem to have a connection with each other, and we see coincidence as highly improbable.

- This has led some people to speculate that there are no coincidences—that everything happens for a reason. This is part of another cognitive bias, the meaning bias, which is the need for the world to make sense or have some meaning.

- This naive assessment ignores all the many events that happen in our lives that do not line up. We experience, hear, see, and dream

thousands of things every day. By random chance alone, events should appear to line up occasionally.

- For example, you dream of a friend you haven't seen in 10 years, and they call the next day. In isolation, it seems amazing, but if there were never any such coincidences, that would be unusual and would demand some explanation.

- The belief in coincidences neglects the fact that there are many people in the world. For example, in a city with one million people, a one-million-to-one coincidence should happen to someone every day. Such stories are likely to propagate because they are compelling, so they spread. Therefore, you're likely to hear stories of improbable coincidences.

- This is also an example of the **lottery fallacy**, in which we tend to ask the wrong questions. For example, what are the odds of John Smith winning the lottery? It's hundreds of millions to one against him winning, so when John Smith wins, we might think that it couldn't have happened by chance alone. The real question is: What are the odds of anyone winning the lottery? It turns out it's pretty good. Someone wins a particular lottery every few weeks. It's a statistical certainty that eventually someone will win.

The odds of anyone winning the lottery are actually pretty good; it's a statistical certainty that eventually someone will win.

- This also relates to the law of large numbers, which states that we are bad at intuitively understanding the probability of very large numbers. What are the odds of someone winning the lottery twice? This seems vanishingly small;

it's hundreds of millions to one against it, squared, but when we consider all people playing all lotteries, the probability is quite good, and this, in fact, happens on a regular basis. We underestimate the probability of events occurring at random.

- Regardless of the mechanism that an alleged psychic uses—tarot cards, astrology, or palmistry—the underlying technique that they're using is called **cold reading**, which counts heavily on confirmation bias. The psychic throws out many statements, and they count on the subject remembering all the apparent hits and forgetting all of the misses; the subject will search for connections that seem to confirm the psychic's guesses, and then they will take that as confirmation.

- Experimentally, after a reading, subjects do tend to remember the hits and vastly overestimate the accuracy of the reading, but when the misses and hits are recorded and counted, there are many more misses than hits.

- Furthermore, we underestimate how high probability some guesses are. This relates to the Forer effect, in which we tend to take vague statements and then apply them directly to something about our lives. For example, how many people know a woman whose first name begins with the letter M? This may sound like a specific statement, but it's a very high probability guess.

Confirmation Biases and Research

- Scientists believe that anecdotes are a very dubious form of evidence because the variables are not controlled and the observations are not systematic. The reason why that is a problem is because anecdotes are a way of subconscious data mining and are subject to confirmation biases, memory effects, and other cognitive biases.

- As with coincidences, with data mining, we are not aware that we are mentally searching through large amounts of data from our everyday lives and looking for patterns. Therefore, seeing a pattern should not be surprising. We should expect, in fact, to see patterns

all the time. Anecdotes are a way of remembering hits and forgetting misses and seeing patterns in a vast, perhaps unappreciated, set of data.

- Apparent patterns seen with data mining need to be confirmed with independent data sets, so a doctor seeing a cluster of patients with the same ailments shouldn't ignore that anecdotal evidence but should use it only as a method of generating a hypothesis. The hypothesis then needs to be tested in a more rigorous or systematic way.

- An example of searching for patterns through large sets of data is the fact that in Psalm 46 of the King James Bible, published in the 46th year of William Shakespeare's life, the 46th word is shake and the 46th word from the end is spear. What are the odds of that occurring? Well, of course, it's vanishingly small. However, what are the odds of some weird coincidence occurring? Because there are so many potential coincidences that could occur, the answer is that, over time, it is certain that a very low-probability coincidence like this will occur on a regular basis.

- Nostradamus is a classic example of **retrofitting**, or the process of looking—after time has passed—for some kind of pattern recognition as a way of mining an inadvertently large data set. Nostradamus was famous for his quatrains, most of which are vague poetic predictions. If you search throughout human history to look for a connection, you may be able to find matches to some of his phrases.

- The problem with Nostradamus's predictions is that they predict too much. You could look at any segment of world history and find some events that seem to match his so-called predictions. Whenever Nostradamus made his predictions specific by mentioning specific names, locations, or dates, they failed miserably.

- People can only find matches after time has passed through retrofitting. In science in general, being able to explain things after

time has passed is not a good predictor of a correct theory. You have to be able to predict things in the future, and that's something that no one has been able to do with Nostradamus's predictions.

Real-Life Randomness

- We have such a poor intuitive sense of randomness that we are incapable of even generating a mathematically random set of numbers. For example, we tend to alternate numbers more often than a random string of numbers would. We avoid lumping or clustering numbers together because clusters of numbers don't look random to us.

- For example, the stars in the night sky are fairly randomly distributed. An even distribution of stars would make it look like a grid pattern, and we probably would recognize that as not being truly random. The point is that the stars in the sky tend to cluster in a way that a random pattern does. Furthermore, we recognize patterns in those random clustering of stars; we call them constellations. This is what mathematicians call the **clustering illusion**: We have a poor, naive sense of the degree to which randomness clusters.

- As another example, diseases tend to cluster. They're not evenly distributed throughout society; they're randomly distributed. The Center for Disease Control and other organizations whose job it is to track diseases find that there are clusters that crop up from time to time. After investigation, they determine that most such reported clusters are statistical flukes, but people who experience the cluster have a strong belief that the effects are real. However, only objective, thorough, rigorous, systematic analysis can determine whether something is a random cluster or a real effect.

- There are many statistically based biases and false assumptions that surround sports. In basketball, for example, we believe that when a basketball shooter is doing well, that he is on a streak and is more likely to make more baskets—called the hot hands effect. When statistically analyzed, there is no real effect. Instead, shooting

streaks tend to follow a random pattern. However, the belief in this effect among players and fans is pervasive.

- Gambling is an exercise in probability, and casinos count on the fact that people are terrible at probability. If you flipped a fair coin and it landed on heads 10 times in a row, what is the chance of flipping heads on the next toss? Intuition often tells us that it's probably less than 50/50: You might think that if you've just flipped heads 10 times in a row, then tails is due or that you're on a streak of heads, so the chances increased. However, if it's a fair coin, there's a 50 percent chance of heads and a 50 percent chance of tails on any flip.

- In fact, there is a fallacy called the **gambler's fallacy**, which occurs in not recognizing the fact that each coin flip is a completely independent event. What has happened previously, therefore, does not have any influence on the future events, and believing this is akin to magical thinking. Gamblers, just like sports fans and players, engage in superstitious, magical thinking to gain some sense of control over the randomness of events.

- **Regression to the mean** is the occurrence of what is called the drunken walk of randomness. As a drunkard will lurch at random to the left or right, a statistical effect may deviate from the statistically average effect but then tend to come back to an average effect—or regress to the mean—by random chance alone.

- Two statistically unlikely events are unlikely to occur in a row. Therefore, players that perform statistically above their average are likely to regress to their average performance. Because statistics doesn't seem like an answer to us, we invent magical thinking to explain this illusory effect of randomness.

- For example, there is something called the *Sports Illustrated* curse. After a player appears on the cover of *Sports Illustrated* for having an above-average year, they will then have a bad year. Regression to the mean alone explains this occurrence. We don't need to

hypothesize that the player became overconfident or sloppy or perhaps was distracted by all the media attention, but we often do.

Important Terms

clustering illusion: The tendency of people to underestimate the clumping of statistically random distributions, which gives the illusion of clustering.

cold reading: A mentalist technique by which the reader can seem to have specific knowledge of the target (the subject of the reading) using vague or high-probability guesses and feedback.

gambler's fallacy: The false belief that prior events dictate the probability of future events, even when they are random and independent, such as the results of random coin flipping.

lottery fallacy: The fallacy of using a specific post-event outcome to calculate the pre-event odds of any outcome. For example, the odds of a specific person winning the lottery may be very low, but that does not mean that the event is too unlikely to have occurred by chance alone because the probability of anyone winning was high.

regression to the mean: A statistical phenomenon in which large deviations from average behavior are likely, by chance alone, to return to more average behavior.

retrofitting: Fitting predictions to known outcomes after they occur.

Suggested Reading

Paulos, *Innumeracy.*

Randi, *The Mask of Nostradamus.*

Vos Savant, *The Power of Logical Thinking*.

Questions to Consider

1. What errors in thinking result from the lack of an intuitive understanding of randomness?

2. How do mentalists use cold reading to appear to have specific knowledge about their targets?

Toward Better Estimates of What's Probable

Lecture 11

This lecture will cover the nature and perception of statistics and probability. Throughout this course, human cognitive strengths and weaknesses are examined, and statistics and probability are general areas of extreme weakness for most people. Of course, however, there is a lot of variation. Some people do have a better mathematical sense than others, but average people have a terrible sense of numbers. Fortunately, it's easy to compensate for our innumeracy with learned skills—specifically in regards to mathematics.

Statistically Based Cognitive Biases

- We tend to overestimate the probability of something happening if we see it, which relates to the availability heuristic. We tend to latch onto examples that are available to us and that we are aware of.

- In fact, we tend to worry about insignificant risks. The risks that are available to us—that are dramatically portrayed or perhaps are related to some deep-seated fear—may be evolved. However, we tend to ignore risks that are much more likely and much more real but that don't capture our attention or are not dramatically portrayed in the media.

- For example, the chance of dying from accidental poisoning in the United States occurs one in 19,400 times per year—many orders of magnitude greater than shark attacks or lightning strikes.

- There is a type of gambling fallacy called playing with house money in which we will tend to increase our bets in a casino over time as we win. This is because we have the sense that we're not playing with our own money—it's money that we won from the house. Therefore, our risk aversion decreases, and we increase the size of our bets. However, the odds have not changed. This fallacy

stems from the tendency to link previous events with future events when they are statistically independent.

- Related to the house money effect is the break-even effect. After losing, we also tend to increase our bets in order to win back our losses. We would rather break even than end a night of gambling having lost. Interestingly, we are more averse to losing than to taking a further risk.

- When gambling over a course of time, you will win sometimes and lose sometimes, which is random—as long as the house isn't cheating. There is usually a small statistical advantage to the house, but if we ignore that, winning and losing will essentially occur in a random pattern.

- When a player is winning, the player is free to keep playing until he or she starts losing. However, when a player is losing, there is no point at which the house is forced to stop. In other words, when a player is losing, he or she is going to run out of money at some point.

People tend to increase their bets in a casino over time as they win because they feel as if they're not playing with their own money.

- In fact, even if there were no statistical advantage to the house, casinos would still rake in lots of money because there is what statisticians call an absorption wall at one end but not at the other. When a player loses all of his or her available money, that's an absorption wall—at which point he or she has to stop gambling. However, when a player is winning, there is no point at which the casino goes broke and the player has to stop gambling.

- Another statistically based cognitive bias is what statisticians call the **base-rate fallacy**. For example, test X for disease A has a false positive rate of one percent and a false negative rate of one percent. Therefore, in the affected population, 99 percent of people will test positive, and in the unaffected population, 99 percent of people will test negative.

- John tests positive for disease A. What is the probability that he actually has disease A? Our naive sense might be that it's 99 percent because that's the accuracy of the test, but the answer actually depends on the base rate—or the broad likelihood of a particular event—of disease A. There is a tendency to fail to consider the base rate when thinking about probability or statistics.

- For example, if one person in 1,000 has disease A, then 10 people per 1,000 will test false positive with test X. A one percent false positive rate over 1,000 people means that there will be 10 false positives in 1,000 people, and there will be 0.99 people who will test true positive. In other words, there will be about 10 false positives for every true positive.

- Therefore, if John tests positive, there is a one in 11, or only about a 0.09 percent, chance that he is true positive, but that's not our naive sense. There's a greater than 90 percent chance that John does not have a disease he tests positive for—even with a highly accurate test that only has a one percent false negative and a one percent false positive rate.

- This has huge implications for screening programs. In the general population, the false positive rate may vastly exceed the true positive rate, depending on the base rate of the disease. This can lead to follow-up tests that may be more invasive and more risky than the screening test that is being recommended. It may cause more harm from unnecessary tests and treatments than is beneficial from early detection.

- This seems counterintuitive: How could a screening program that detects disease early actually hurt people? When the base rate is low enough, the false positive rate can vastly outnumber the true positive rate, leading to unintended consequences of complications and side effects from further testing and interventions that result from those false positive tests. In designing a screening program, you always have to consider the base rate.

Overestimation and Probability Puzzles

- In estimating probability, we tend to be favorable to ourselves because of our need for self-esteem. We like to think positively about ourselves and to present ourselves positively to others. We, therefore, tend to overestimate our own ability, which is called **overprecision**. Additionally, we tend to overestimate our relative ability compared to others, which is called overplacement.

- Probability puzzles are a good way to demonstrate our inherent lack of intuition about probability. For example, how many people would you need to have in a room in order to have a greater than 50 percent chance that two of them share a birthday? The answer is only 23, but most people naively guess that the number is much higher. Similarly, how many people would you need to have in a room for there to be a 97 percent chance that two of them share a birthday? The answer is only 50 people.

- In the Monty Hall problem, you are playing Let's Make a Deal with Monty Hall, and you have three doors in front of you. Behind one door is a new car; behind two doors are goats. You are asked to select a door, and of course, you are trying to select the door that

has the new car behind it. It's important to note that Monty Hall knows where the car is.

- You make your guess, and then regardless of what door you guess, Monty Hall will open up one of the other doors to reveal a goat. He then asks you if you would like to change your choice to the remaining door or stick to your original choice. What should you do?

- The intuitive answer that many people give is that it doesn't matter whether you choose a new door or stick with your original guess; either way, your chance of winning is 50/50 because there are two doors left, and one has a goat while the other one has a car.

- However, the truth is that if you stick with your original guess, your chance of winning is one-third. If you switch to the new door, your chance of winning increases to two-thirds.

- To understand this problem, it's key to remember that Monty Hall is giving you new information by opening up one door and revealing a goat because he knows where the goats and the car are.

- Initially, when you pick one of the three doors, your chance is one-third, and it remains one-third if you stick with that choice. However, if you wish to switch to the other door, in essence, you are switching to the other two doors because no matter what you chose the first time, Monty Hall will reveal a goat. Because you're choosing two doors at the same time, your odds increase to two-thirds.

Real-Life Innumeracy

- **Multilevel marketing** schemes prey on our innumeracy. To maintain the pyramid structure of a multilevel marketing scheme, geometrically more people would have to be recruited.

- For example, salespeople are encouraged to increase the number of people they recruit, who then sell for them. Sometimes they're

required to recruit a certain minimum number of people in order to make back their investment. Then, the recruited people have to recruit the same number of people to make back their investment. These progressions are inherently unsustainable, and we underestimate how quickly a community, city, region, or even the world can be saturated with any multilevel marketing program.

- It's also very easy to use the public's naive sense of statistics to create an impression that is misleading. A very common example that crops up with medical issues is the difference between relative risk and absolute risk. For example, one person in 10,000 gets disease A, and an environmental risk factor increases that to two in 10,000. The relative risk is 100 percent, or double. However, the absolute risk only increases to two out of 10,000, or 0.02 percent. Therefore, the relative risk can be used to exaggerate the effects of both risk factors and treatments, and it is misleading if it's not made clear which type of risk you're dealing with.

- Another common statistical fallacy is called the **sharpshooter fallacy**, whose name alludes to an analogy of shooting a gun at the side of a barn and then drawing a target around the hole, claiming that you shot a perfect bull's eye. This might seem like an obvious fallacy, but it's amazing how often that kind of behavior occurs but is hidden in more subtle ways.

- The sharpshooter fallacy relates to choosing criteria, or interpreting the significance of those criteria, after you know what the outcome is, which is called post-hoc analysis. Furthermore, this relates to our developed ability to mine data for patterns and make connections.

- For example, researchers have found many apparent connections between the assassinations of Abraham Lincoln and John F. Kennedy, such as the fact that the assassin who killed Lincoln shot him in a theater and then ran to a book depository whereas Kennedy's assassin shot him from a book depository and then ran to a theater. After time has passed, these coincidences seem amazing, but it's simply post-hoc analysis.

Important Terms

base-rate fallacy: Failure to consider how common a phenomenon is (the base rate) when estimating how likely it is, preferring other factors such as representativeness.

multilevel marketing: A corporate structure in which salespeople must pay a percentage of their profit to sponsors above them and, in turn, can sponsor salespeople below them who have to pay them a percentage.

overprecision: A psychological term that refers to the tendency for people to overestimate the accuracy of their own knowledge.

sharpshooter fallacy: Choosing the criteria for success specifically to match the results that are already known.

Suggested Reading

Dewdney, *200% of Nothing.*

Mlodinow, *The Drunkard's Walk.*

Questions to Consider

1. How is knowledge of statistics and probability critical to medical diagnosis?

2. Why are most participants in multilevel marketing doomed to lose money?

Culture and Mass Delusions

Lecture 12

In addition to our evolved tendencies and personal quirks, we are strongly influenced by those around us and our culture. We can even get caught up in group or mass delusions. This lecture will discuss the effects of delusions and culture on our beliefs. The fact is that people are social as well as emotional creatures. We respond to the beliefs of others, to our social group, and to the broader culture. It's important to keep your critical thinking active and not to surrender to these group dynamics.

Delusions of Individuals

- A delusion is a fixed belief that is not changed even in the face of overwhelming contradictory evidence. When delusions occur in an individual, the tendency to form delusions is considered a symptom of a mental illness.

- The most common example of a mental illness that is described as a tendency to form delusions is schizophrenia, but in reality, delusions occur on a spectrum—with schizophrenia being only at the most severe end of that spectrum.

- To varying degrees, even healthy, normal individuals can have delusions. We all have this tendency, and as it becomes more severe, we may consider it a disorder at some point. When less severe, we may consider it a personality trait.

- In essence, a delusion involves impaired reality testing and being compelled by the patterns we imagine we see in events around us.

- There are various types of delusions. A paranoid delusion is one in which we think that people, organizations, or events are conspiring against us. We see a pattern of action that is against our interests.

- Grandiose delusions are fixed beliefs about our own ability. As previously mentioned, all of us have a tendency to overestimate our own ability, but a grandiose delusion takes that further.

- There are also personal empowerment delusions, such as the delusion that one might have the ability to fly, and there are delusions of hopelessness, which occur with severe depression. One fascinating manifestation of this type of delusion is that some people who are very depressed suffer from the delusion that they are dead; it is the only way they can make sense of the physical sensations they have.

Delusions of Groups

- Delusions can affect more than just an individual person at one time. A **folie** à **deux** is a delusion shared by two people. Typically, there is a dominant person, the one with the fixed delusion, which is where the delusion originates. There is also a more passive partner, who is considered to be the recipient of the delusion.

- A folie à deux delusion tends to occur in isolation with a very close intimate relationship. The delusion usually resolves in the induced or passive individual with separation, although it does not resolve in the dominant or originating person because they're the ones with the disorder.

- When more than two people share a delusion, it's called a **group delusion**, which occurs in a small group of people. This could be a family or perhaps even an isolated cult. Often, there is a charismatic or totalitarian leader to the group.

- Group dynamics are the dominant factor in group delusions. Typically, individual members of the group surrender their will to the charismatic leader, who causes them to turn off their capacity for critical thinking.

- Additionally, conformity with the social group is emphasized with group delusions. This is a natural tendency that humans share, but

group delusions emphasize conformity beyond normal amounts. This may also involve a theme of us versus them, of purity, or of salvation.

- The Heaven's Gate cult is an example of this type of group delusion. Marshall Applewhite was a charismatic cult leader who led a group of about 40 members to engage in a suicide pact and commit suicide. They believed that they needed to leave their physical bodies so that they could ascend to an alien-guided spacecraft, which was passing Earth behind Comet Hale-Bopp.

Mass Delusions

- A **mass delusion** occurs when more than a small group is involved in a delusion. Psychological factors, illusions of perception, fallacies, fantasy creation, and social conformity are factors that are involved in the various types of mass delusions.

- In a community threat, there is an exaggerated sense of danger that can persist for weeks or even months. It will tend to come and go in waves, so the level of panic is not always persistent or constant. It does not result in a panic or a fleeing from the community, so it is essentially a low to moderate level of continuous anxiety that is increasing and decreasing over time.

- An example of this is the Seattle windshield-pitting epidemic of 1954, in which there was widespread belief that pitting damage was being done to windshields. The damage was first blamed on vandals, but once it became more widespread, there were fears of it being something dangerous, such as radioactive fallout. Reports of windshield pitting were reinforced by the media, but investigations revealed that people were just noticing pits that had been there all along. In essence, this windshield-pitting epidemic was created out of social means and contamination.

- A **community flight panic** is similar to this type of panic but is more short term and acute. It typically lasts for hours to days as opposed to weeks or months. Panic spreads very quickly, resulting

in some people actually fleeing the local area. Because the fear is about something that is imminently about to happen, when it doesn't happen after a few days, the fear will then subside.

- Perhaps the most iconic example of the community flight panic is the incident of Orson Welles telling a story by H. G. Wells. On Halloween eve in 1938, a radio broadcast of *The War of the Worlds* was dramatized by Orson Welles. However, he reconfigured the story so that it was given in the form of dramatic news flashes, and the story was transposed so that the locations were in contemporary America as opposed to the original setting of the story in England. Many people tuned in late to the broadcast and missed the introduction to the story. In addition, radio was a new form of mass media, and people expected to hear news on the radio—not fiction.

- As a social species, we are programmed to respond to the fears and the panic of other people in our community. Community flight panic is simply that defensive or adaptive mechanism going out of control in response to a false or delusional panic.

- There are also larger delusions that go beyond just a single small community that are called **symbolic community scares**, which tend to wax and wane over years. These can involve entire countries and even continents. They often involve fears of a moral or existential threat that derive from some cultural fear that is held by many people in a broad culture or community.

- For example, threats from immigration represent this type of community scare, in which there is the perception that out-of-control immigration is allowing unsavory or perhaps criminal segments into a society to the extent that the purity, the safety, and the very makeup of a society is being threatened by this long-term phenomenon.

- **Witch hunts** are perhaps the most iconic example of this type of mass delusion. In the United States, the Salem witch trials of

1692 led to the conviction and execution of 19 people. However, the same thing happened in Europe between 1470 and 1750, during which an estimated 40,000 to 100,000 witch executions took place.

Library of Congress, Prints and Photographs Division, LC-USZ62-94432.

The witch trials of 1692 that took place in Salem, Massachusetts, serve as an iconic example of mass delusion.

- **Collective wish fulfillment** is a type of mass delusion that is similar to a symbolic community scare, but it involves something desirable rather than a deep-seated fear.

- A classic example of collective wish fulfillment is the fairy sightings that were common in Europe in previous centuries. Typically, these types of sightings are culturally specific. In other cultures, this may manifest as Virgin Mary sightings or UFO sightings.

Mass Hysteria

- **Mass hysteria** is similar to mass delusion, but it is different in that it specifically involves physical symptoms. The term hysteria has fallen out of favor recently because of its cultural misogynous roots; however, the term mass psychogenic illness means essentially the same thing and has largely taken its place.

- Mass psychogenic illness episodes are characterized by having a rapid onset and resolution of symptoms. They tend to spread by social information contact; in essence, the information is considered to be the contagion that spreads the psychogenic illness. Often, the alleged illness lacks biological plausibility, and the symptoms tend

to be vague and nonspecific—the kind of symptoms that even a healthy person can have from time to time.

- A classic example of mass psychogenic illness is the Pokémon panic of 1997. Pokémon, a Japanese cartoon, involved battles in which an electrical attack was portrayed by flashing lights, creating a strobe effect. It is true that some children have photosensitive epilepsy and could have had seizures as a result of seeing such images, but the few cases of legitimate seizures led to hundreds of children reporting episodes. In reviewing the reports, it seemed that the symptoms spread through information contagion, although the panic was triggered by what were probably some real seizures.

- Another common example is called the **sick building syndrome**. This involves buildings in which many people report symptoms, often over a period of years. This has even led to buildings being torn down and rebuilt to get rid of whatever it was in the building that was causing the illness.

- There may be genuine environmental cases of something in a building that is an irritant and can cause symptoms; however, upon careful investigation, many of the cases reveal no environmental contaminant or cause of the symptoms. The symptoms are often vague, nonspecific, common symptoms that occur frequently in daily life, including dizziness, headaches, blurry vision, and shortness of breath.

- There are also many product rumors. For example, the idea spread that silicone breast implants could cause autoimmune diseases, which led to the belief among many women who had silicone breast implants and autoimmune diseases that it was the implants that caused their illness. This led to multiple lawsuits, but after all the data was carefully analyzed, it turns out that there was no increased risk of getting any autoimmune disease in women who had breast implants.

- Often, such rumors are promoted by poor investigations and media reports—for example, poor questionnaires that ask leading questions or selective anecdotes.

- Another form of these types of rumors is **urban legends**, which represent cultural fears and anxiety. They spread by word of mouth, and now with the Internet, they spread even more rapidly.

- One example of an urban legend is the claim that a fast-food restaurant accidently served a customer a fried rat—something that has never been documented to occur. This urban legend is probably based on our fear of being served food by others that we don't completely control.

Important Terms

collective wish fulfillment: A form of mass delusion characterized by the fulfillment of a common desire or wish, such as making a fantastic discovery.

community flight panic: A form of mass delusion in which fear or an immediate threat spreads through a town or community, causing many to flee from the alleged threat.

folie à deux: A shared delusion between two individuals, in which one person tends to be dominant and the source of the delusion.

group delusion: A delusion shared among a small group, such as a cult, typically led by one charismatic leader.

mass delusion: A delusion or false belief shared among a large group of people—even an entire community or culture.

mass hysteria: Similar to a mass delusion but specifically involving physical symptoms.

sick building syndrome: A form of mass hysteria centering around a building that is believed to be the source of a mystery ailment.

symbolic community scare: A long-standing mass delusion that tends to wax and wane over years and is centered around a perceived existential threat to the community.

urban legend: A false belief or story that represents a common fear or anxiety in society and spreads largely through rumor.

witch hunt: The persecution of a person or group using accusations of heinous acts, or association with such acts, and using dubious investigating techniques designed to achieve the conclusion of guilt.

Suggested Reading

Bartholomew, *Little Green Men, Meowing Nuns, and Head-Hunting Panics*.

———, *Panic Attacks*.

Mulhearn, "The Psychology of the Witch-Hunt."

Questions to Consider

1. What do documented historical cases of mass delusion teach us about the human capacity to form and hold false beliefs?

2. What role does the media play in spreading urban legends and mass delusions?

Philosophy and Presuppositions of Science

Lecture 13

In this lecture, you will learn about the philosophical basis for how we know what we know, or epistemology. Specifically, the philosophical underpinnings of science—including methodological naturalism, scientific methods, and the limits of science—will be addressed. You will also learn about scientific reasoning, such as the application of Occam's razor. In addition, the history of science reveals a great deal about science as a human endeavor and how ideas emerge and evolve within science, so this lecture will also address the views of philosopher Thomas Kuhn and post-modernist challenges to science.

Science and Philosophy

- Science can only exist within a specific philosophical framework. The philosophy of science defines the assumptions, methods, and limits of science. In this way, philosophy and science are complementary intellectual disciplines.

- Science is the foundation of critical thinking; it involves the methods for testing our beliefs about the natural world. The strengths of science are that it is transparent, rigorous, systematic, and quantitative. In other words, science is a system of methods that seeks to compensate for the failings of human thinking, perception, and memory.

- The discipline of philosophy that deals with knowledge is called **epistemology**, which deals with how we know what we know—the nature of human knowledge. It addresses questions about what can be known, even in theory.

- The specific philosophy under which the methods of science practice is called methodological naturalism, which states that material effects must have material causes. The material aspect refers to the

stuff of the universe, which is not limited to macroscopic matter. Methodological naturalism also follows natural laws.

- **Philosophical naturalism** is similar to methodological naturalism; it is the philosophical stance that the material universe is all that there actually is.

- Science, however, does not require such a belief, but it does require that we follow the methods that assume there is nothing beyond the natural world—or that we, in other words, do not rely upon any supernaturalism.

- Science does make assumptions about the world. There is, for example, an objective reality. If we weren't living in an objectively real universe, then it would not be possible to investigate how that universe works.

- Science also assumes that the world is predictable and, therefore, ultimately knowable. Furthermore, science does not dictate that these things are true, but it requires the assumption that they are true.

- There is not a single scientific method; it's a collection of methods. At the core of scientific methods is the notion of hypothesis testing, or formulating an idea in a manner that it can be theoretically and practically subjected to objective testing. This includes the notion that the idea must be able to be proven false.

- Testing is not limited to laboratory experimentation; it could involve further observations of the world around us or inferences based on direct evidence. As long as evidence is gathered in a systematic way that can be for or against one or more theories, then the notion is testable and involves science.

- Historical science has often come up in this context. We cannot, for example, rerun the big bang in a laboratory. However, we can ask questions about the existence and nature of the big bang

and then make observations that test those theories. For example, we can make observations of the cosmic background radiation, the radioactive noise that was left over after the big bang.

The evolution of various species cannot be re-created in the laboratory, but inferences can be made from fossils.

- We cannot go back in time to witness evolution happening, but we can make inferences from fossils, genetic evidence, and developmental biology. Furthermore, we can see components of evolution in laboratories.

- Science also needs to be understood as a human endeavor. Therefore, science is imperfect and messy, has many false steps, and is plagued with bias and error. Fortunately, science is also self-correcting, which is perhaps its strongest feature.

- There is also not one pathway of science. An observation leads to a hypothesis—which is a guess about what is responsible for the observation—that is then tested by an experiment. After the results of the experiment, the hypothesis is refined. Then, the experimental phase is repeated.

- However, science doesn't necessarily always follow in that same order. For example, we may make observations in light of existing theories, and those theories may bias the way in which we make those observations. We may find inspiration from many sources that are chaotic, culturally dependent, and determined.

Philosophers and Physicists

- Philosopher Thomas Kuhn developed the idea of **paradigms**, which are large, overarching ideas. Scientific progress, he argued, is divided into periods of normal science, in which there is slow progress and the refinement of ideas within a paradigm, and is punctuated by periods of scientific crisis, in which problems cannot be solved by tweaking an existing paradigm. This leads to a paradigm shift, in which an explanatory model is entirely replaced by a new one.

- Kuhn's ideas were used to further develop the **post-modernist** view that science is culturally dependent and not progressive. Post-modernists took that view to the extreme by believing that the process of one paradigm becoming replaced by the next was not inherently progressive and that paradigms could only be assessed within their own framework.

- Kuhn rejected these ideas, arguing that there is copious evidence that progress does occur in science. Some ideas in science are better than others, and the long history of science is characterized by a slow, continuous grinding forward of producing increasingly better models of how the world works.

- Kuhn's model was criticized as a false dichotomy. In reality, there is a continuum of degrees of progress within science—from tiny steps to major shifts in our scientific thinking.

- Philosophers of science have largely moved beyond the post-modernist view; they now understand that this view was extreme and not an accurate description. In fact, the specific criticism is that this view confused the context of discovery, which is chaotic and culturally dependent, with the context of later justification. Regardless of how new ideas are generated in science, they are eventually subjected to systematic and rigorous observation, experimentation, and critical review. It is later justification that gives science its progressive nature.

- Another philosophical objection raised is the notion that science cannot prove itself. Philosophically speaking, this is true, but it's irrelevant because the philosophy of science doesn't claim that it has objective metaphysical certitude. Science works within the philosophical framework of science.

- However, we can say that there has been a meta-experiment of science. If all of the assumptions of science are correct, then the endeavor of science should produce some objective, positive results over time.

- In classic physics, by the end of the 19th century, there was a Kuhnian crisis. The physics of the time could not explain several observed phenomena, including the orbit of Mercury, the ultraviolet catastrophe, and the absence of ether.

- For example, physicists were trying to figure out what light moves through. At the time, the Maxwell equations told us that light travels at a constant speed—but with respect to what? They initially believed in the possibility of an ether through which light propagates, but research subsequently showed that the ether did not exist.

- Albert Einstein was the first to consider that space and time are relative and that the speed of light is constant with respect to everything. He completed his special theory of relativity in 1905. Perhaps, this was the most dramatic paradigm shift in scientific history—from a classical universe to a relativistic universe.

- However, despite the explanatory power of his theories, Einstein's relativity was not accepted until it was confirmed by later observations and experimentation; therefore, the real credit goes to the context of later justification.

Science at Its Best

- Scientific methods are used to develop a model of how the world works. Hypotheses and theories are only useful to the extent that

they can explain nature, but explanation is not enough. They must also make predictions about observations that have not yet been made and that can be tested.

- There are competing theories in science. When there is more than one explanation that can account for data we already have, there must be a way to separate them experimentally. A theory is, therefore, only useful if it makes predictions that are different than other existing theories. Often, the most challenging aspect of science is figuring out how to test something.

- If we have more than one theory that can explain all of the data that we have and there is no empirical way to separate those theories, then we can employ a philosophical rule of thumb called **Occam's razor**, or the rule of parsimony, which states that the theory that introduces the fewest new assumptions is preferred. This doesn't mean that the theory that has the fewest new assumptions is correct, but it at least should be preferred until eliminated.

- Otherwise, we could endlessly generate ad-hoc theories to explain any phenomenon. This is limited only by human creativity, which is fairly extreme. If you can eliminate an element from a theory and it makes no difference to the predictions or observations, then eliminate it.

- Science also needs to be understood as a provisional endeavor. All conclusions in science are subject to further evidence and new ways of interpreting the data. There's no metaphysical certitude, which means that scientists and critical thinkers need to be comfortable with uncertainty. All data has error bars around it, but this does not mean that we do not know stuff or that we cannot use the methods of science to build reliable models about how the world works.

How Science Progresses

- The way in which science progresses depends on where along the progressive model a scientific theory is. In the beginning, the progress of science is similar to Kuhn's paradigm shift model.

However, the more a scientific discipline develops, the less it resembles this dramatic paradigm shift and the more it resembles a process of refinement.

- The ancient Greeks knew that Earth was a sphere as a result of some basic observations. However, once explorers could sail around the world and measure it more accurately, they realized that it's actually an oblique spheroid—it bulges more around the equator than around the poles. This method was later replaced by modern satellite measurements that were able to detect that it is also an asymmetrical oblique spheroid, meaning that the southern hemisphere is slightly larger than the northern. Therefore, the notion that Earth is a sphere is not wrong; the newer measurements were simply refinements. We will not discover tomorrow, for example, that Earth is a cube.

- Many sciences are established to such a high degree that while refinements are always possible, fundamental knowledge will not be overturned. For example, although we are always learning more about the details of genetics and how DNA translates into developmental biology, the basic fact that DNA is the molecule of inheritance is not going to be overturned.

Important Terms

epistemology: The branch of philosophy that deals with knowledge and the methods of science.

Occam's razor: A rule of thumb, also known as the law of parsimony, that states that when two or more hypotheses are compatible with the available evidence, the one that introduces the fewest new assumptions is to be preferred.

paradigm: A term developed by Thomas Kuhn to refer to a set of scientific beliefs and assumptions that prevail at any particular time in history.

philosophical naturalism: The philosophical position that the natural world is all that exists—that there is nothing that is supernatural.

post-modernism: A school of philosophical thought that treats all knowledge as equally valid social constructs or narratives.

Suggested Reading

Asimov, *Asimov's New Guide to Science.*

Klemke, Hollinger, and Rudge, *Introductory Readings in the Philosophy of Science*.

Novella, "The Context of Anecdotes and Anomalies."

Questions to Consider

1. What is the core methodology that defines legitimate science?

2. What is the major critique of the post-modernist approach to science and scientific knowledge?

Science and the Supernatural

Lecture 14

This lecture will explore the differences between philosophical and methodological naturalism and what is meant by the term supernatural. Are there such things as miracles, and can science ever answer such questions? What is or should be the relationship between science and religion? Progress over time is a more telling feature of science than the fact that at any given time there are anomalies we can't explain. There are always going to be anomalies—until science has explained everything about the universe.

Addressing Falsifiability

- Science is dependent upon methodological naturalism, which holds that material effects must have material causes. This is not an arbitrary choice, as some may claim. The methods of science simply do not work without this underlying philosophical basis.

- This is because nonmaterial causes cannot be falsified; therefore, they fail to meet a necessary criterion for science. The reason they can't be falsified is that they are not constrained in any way. There are no limits to what they can potentially do because they are not, by definition, following the laws of nature—of material cause and effect. Furthermore, constraint is necessary for **falsifiability**.

- For example, how are the characteristics of ghosts constrained? How could we falsify the hypothesis that ghosts are responsible for any particular observed phenomenon? If they are outside of what we understand as the law of nature, then they could theoretically do anything. If they could do anything—if they're unconstrained—then they are untestable by the methods of science. In other words, is there any observation or experiment that is not potentially compatible with the hypothesis that ghosts exist? If the answer is no, then ghosts are simply an unscientific notion.

- Other examples of claims that cannot be falsified might include the notion that life is the result of creation. This is often defended by saying that the world was created recently but was made to look as if it is ancient. We could likewise argue that the world was created five minutes ago but was created to appear as if it is ancient. Such notions are not falsifiable in the way that they are constructed; therefore, they are not science.

- Another way in which creation beliefs are unfalsifiable is that the creator as an entity, by definition, is not constrained in any way scientifically. The creator could potentially, therefore, have created life to look like anything—even as if it had evolved. Therefore, any observation of the natural world is compatible with creation; as a result, creation is unfalsifiable and not a science.

- Phillip E. Johnson is credited with founding the intelligent design movement. He argues for what he calls theistic realism. Essentially, he has been on a campaign since the early 1990s to allow supernatural explanations back into the realm of science. He and others argue that the rejection of supernatural explanations is nothing more than prejudice.

- This philosophical debate was fought in previous centuries. Philosophers already wrangled with this idea of the relationship between supernaturalism and scientific methodology, and it was realized by these philosophers that supernatural or miraculous causes cannot be introduced into scientific explanations because they're not constrained and not falsifiable.

- Philosopher Bertrand Russell came up with an analogy to explore the relationship between testable and untestable claims when making theories and hypotheses that is now known as **Russell's teapot**: Imagine someone claiming to believe that there is an ordinary teapot in orbit around the Sun somewhere between the orbits of Earth and Mars. This could be a small, dark object—not visible by any instrument we have on Earth. We do not have any probes in outer space that could, theoretically, detect such a thing,

and even if we did, space is an awfully big place. The amount of territory between the orbits of Earth and Mars are so great that we can have dozens of probes looking for centuries and would still have an insignificant chance of detecting Russell's teapot in a lonely orbit around the Sun. Therefore, the teapot cannot, in practical terms, be proven not to exist. However, does that mean that it's reasonable to conclude that it, therefore, does exist and to promote a belief in this teapot?

- Russell used this example to make the point that the burden of proof for any scientific claim lies with those making the claim. The inability to prove something false is not sufficient justification for the claim. Furthermore, there are endless potential claims that cannot be practically or theoretically falsified.

- This also raises the issue of proving a negative in science. While it's not possible to absolutely prove a negative in terms of proving the nonexistence of something, you might be able to demonstrate that something is impossible, given what we know about the laws of science and nature.

- The conclusion that something like Russell's teapot does not exist can only be as good as the extent to which a thorough search for that thing has been conducted. Such searches are typically always incomplete and tentative. Still, this is not a justification for a positive claim.

- What if all other explanations for a phenomenon have been ruled out? This is an argument from ignorance. Ruling out competing hypotheses means the phenomenon is simply unknown. There can always be other possibilities that we are currently unaware of, but this is related to another logical fallacy: confusing what's currently unknown with what's unknowable.

The Epistemological Limits of Science

- Science only deals with scientific claims, meaning that any claim can be theoretically rendered scientific by being stated in a way that

is theoretically and practically testable and falsifiable. Interestingly, almost any claim can be rendered scientific if it is systematically insulated from falsification.

- Paranormal researchers—those who promote beliefs in the supernatural—often try to have it both ways. They claim scientific evidence for the paranormal but then argue that the paranormal cannot be disproved. Any evidence against the paranormal phenomenon can be dismissed by saying that science cannot test it. Then, they employ special pleading in order to remove the claim from the arena of science.

- A claim must either be within or without the boundary of scientific investigation. Science can only be **agnostic** toward claims that cannot be tested, although philosophically it can be concluded that such hypotheses are unnecessary. For example, Occam's razor can be invoked also to favor parsimony.

- How can we operationally define paranormal or supernatural? Anything within the natural world is, by definition, natural and not supernatural. For anything that has an effect on the world, that effect can be theoretically detected and measured. One could argue that any phenomenon that is unknown is simply currently unknown and is not necessarily paranormal.

- Could we define paranormal as any phenomenon that is not just unknown but actually does not follow the laws of nature? This is not confined by the known universe and is unfalsifiable. The normal laws of nature are suspended or violated in the phenomenon that is therefore supernatural.

- Hypothetically, in a paranormal world, the best science could do is identify anomalies, which are things that cannot be explained by our current understanding of the laws of nature. Because, by definition, a paranormal phenomenon could not be explained by the regular laws of nature, such anomalies would remain forever unexplained

by science. This would still not result in positive evidence for the paranormal—just a persistent argument from ignorance.

- However, if there were longstanding, persistent anomalies, that would at least be interesting, and it would hint that there was some aspect to the universe that science is missing. Could we then know that we lived in a supernatural or paranormal world? Additionally, what does it mean to be persistent?

- The scientific endeavor is only really a few centuries old and has only been institutionalized and robust for the last 100 to 200 years. Therefore, we don't have a long enough experience with systematic scientific investigation of the natural world to have a sense of how long an anomaly might persist before we solve it.

- There have been questions in science that vexed scientists for decades, but then we ultimately did solve those problems. What if such anomalies persisted for not just decades, but for centuries or even millennia? Is there any point at which we would determine that a particular anomaly would never be solved by science and, therefore, would point to a supernatural or paranormal world?

- The history of science is one of fairly steady progress, and this speaks well for the philosophy of methodological naturalism. The anomalies of yesterday have largely been solved and have been replaced by new, deeper anomalies. As science progresses over time, our answers become more subtle and our knowledge becomes increasingly deeper.

- The scientific approach is to never give up, and concluding that a phenomenon is paranormal or supernatural is akin to giving up. Science assumes that anomalies are ultimately understandable and then proceeds along the empirical path of scientific investigation. At least so far, this approach has worked out to be very practical and useful.

- Miracles are basically the same as paranormal phenomena; they are events or phenomena that appear to defy the laws of nature. In order to label a phenomenon as a miracle, it still requires an argument from current ignorance.

Faith and Science

- In the scientific sense, faith is belief without knowledge; it involves believing in something for reasons other than empirical evidence, logic, and philosophy. Whether faith and science are incompatible depends on how you define and approach each.

When considering whether faith and science are incompatible, define what questions can and should be addressed by each.

- People are free to believe what they will about unanswerable questions—those that are outside the realm of science and to which science can only be agnostic. There are also certain kinds of questions that are inherently outside the realm of science: questions of value, aesthetics, and moral judgments. These cannot objectively be resolved by empirical evidence. Even when science can inform such questions, they are not ultimately within the epistemological limits of science.

- Paleontologist Stephen Jay Gould coined the term **nonoverlapping magisteria (NOMA)** to describe his approach to this question, which was to separate faith and science into different magisteria, or different intellectual realms. He said that science deals with empirical knowledge of nature while faith deals with areas of morality and judgment—things that could not be ultimately decided with empirical evidence.

- This would mean that faith should not be used to address questions that can be answered by science—nor should faith be used to limit what science can investigate. At the same time, scientific methods should not be used to address questions that cannot be investigated scientifically because they are not falsifiable. Science can only be agnostic toward untestable notions. The important thing is to define what questions can and should be addressed by science and not to confuse the two.

- It's most important to keep scientific and unscientific questions separate. Therefore, we should not defend bad science by saying that it cannot be tested by science because, then, such propositions are outside the realm of science and become faith.

Important Terms

agnostic: The notion that unfalsifiable hypotheses, such as the existence of God, are not only unknown—but are also unknowable.

falsifiability: The key feature of any scientific hypothesis—that, at least theoretically, there must be some evidence to prove or imply that the hypothesis is not true.

nonoverlapping magisteria (NOMA): The term coined by Stephen Jay Gould to describe his philosophy that science and faith are separate and nonoverlapping schools of thought.

Russell's teapot: A hypothetical teapot proposed by Bertrand Russell that is orbiting the Sun between Earth and Mars to make the point that not all claims that cannot be proven false should be accepted as true.

Suggested Reading

Hines, *Pseudoscience and the Paranormal.*

Newberg and Waldman, *Born to Believe.*

Novella, "New Scientist on Miracles."

———, “Science and Faith.”

Shermer, *How We Believe.*

Questions to Consider

1. Can science ever prove a phenomenon that is alleged to be paranormal or miraculous?

2. What are the implications of anomalies that are currently unexplained by science?

Varieties and Quality of Scientific Evidence

Lecture 15

There are many different kinds of evidence in science: experimental versus observational, exploratory versus confirmatory, and basic science versus applied science. Scientific evidence is also dependent on the statistical evaluation of data, which can take many approaches. This lecture will provide the tools for evaluating the nature and strength of scientific evidence. The complexity of designing scientific studies and evaluating the literature is a way of compensating for the flaws and weaknesses in our brains. It's important to use the evidence to figure out what is true—not to defend what you wish to be true.

Experimental versus Observational Studies

- If you want your beliefs and conclusions to be based on solid evidence, then you have to know how to interpret evidence, but it is not always easy or obvious how to do so. There are different kinds of evidence that each have different strengths and weaknesses.

- On any complex topic, there's going to be contradictory evidence, so you can't look at any single piece of evidence and get a full picture as to what is going on. You need to know some methods of balancing and comparing the different kinds of evidence.

- In order to make sense of the scientific evidence, you need to know how to assess an individual study. Then, you need to be able to pull it all together, balancing all of the available evidence to compare different studies to each other.

- The different kinds of scientific studies are roughly divided into two broad categories: experimental and observational. **Experimental studies** are designed to perform a specific intervention; they do something to affect nature or people and then measure some specific outcome.

- The goal of a well-designed experimental study is to control for as many specific variables as possible. Ideally, one variable will be completely isolated so that the effects of that variable can be determined.

- There are many examples of experimental evidence. For example, scientists can inject a drug versus a placebo, or fake drug, into lab rats and then measure some specific outcome.

- The strengths of experimental studies include controlling and isolating variables. They also can be highly quantitative; you can measure some specific feature or outcome. You can also perform specific statistics on the numbers you obtain because there are comparison groups.

- There are also weaknesses to experimental studies. They may not represent, for example, real-world experiences. Often, they're not practical. For example, we cannot withhold a known effective treatment or randomize people to be exposed to some toxin or other risk.

- On the other hand, **observational studies** observe the world without doing any specific intervention—or with only minimal intervention. For example, you can correlate a risk factor to a disease. For example, how many people who smoke get lung cancer compared to those who don't smoke?

- The strength of observational studies is that they can gather large amounts of data just by looking at the data that already exists. You're also able to compare different groups, and the minimal intervention reduces the risk of affecting the natural behavior of the system that you're looking at.

- There are also weaknesses to observational studies. Observational studies do not control many variables, although you can try to account for as many variables as you can think of. Therefore, observational studies are always subject to unknown variables—

those that you haven't thought of or that cannot be accounted for. Observational studies generally can only demonstrate correlation; they cannot establish definitively cause and effect.

- Experimental and observational evidence are complementary types of evidence. They work together to provide different kinds of information with different strengths and weaknesses.

Examining the Data

- Studies with only a few subjects—whether it's observational or experimental—are likely to be erroneous or quirky. Large studies are needed for random effects to average out.

- The **statistical significance** of results is often expressed as a **P value**, which is the probability that you would have gotten the results that you did, or greater, given the null hypothesis, which is the hypothesis that the phenomenon you're studying does not exist as opposed to the evidence establishing that the phenomenon you're looking at does exist.

- However, statistical significance is not everything. A systematic flaw or bias in how a study is conducted, whether experimental or observational, can systematically bias the results in one direction. If you do enough trials, this can produce statistically significant results; however, they will be erroneous because they're representing some bias in the study.

- Therefore, you also need to consider the effect size, or how large the effect is. The smaller the effect size, the greater the probability that some subtle bias was the result of that outcome. It becomes increasingly difficult to detect and weed out increasingly subtle biases; therefore, very tiny effect sizes are always tricky to deal with.

- You also have to be suspicious of effect sizes that are right at the limit of our ability to detect them or that are similar in magnitude to the noise in the data—even if it's highly statistically significant.

- You also need to consider whether the data collection was systematic and continuous. For example, if people are being surveyed, did everyone answer the survey? Were the responders self-selective? Was there some bias to the way people were chosen?

- In a study of patients, was every patient, or were sequential patients, included? For example, did the patients who had a good response from a drug come back for follow-ups while patients who did not have a good response not come back?

- What was the dropout rate of the study? This potentially introduces a further bias into the results. It's possible that some subjects simply do not follow up with the study. A dropout rate of greater than 10 to 20 percent seriously reduces the reliability of a study and calls the results into question.

- In other words, is all the data being counted? It's easy to create false results if only a subset of the data is counted—for whatever reason. Skipping, dropping, or selecting data can systematically bias results, making the outcomes misleading.

- You can also ask whether a study is prospective or retrospective. A **prospective study** chooses subjects or objects to be observed and then observes their behavior and outcome. A **retrospective study** looks back at events and outcomes that have already occurred. Prospective studies are considered to be more rigorous because they are subject to fewer confounding factors.

- Another critical aspect of a study is whether it is **blinded** or double blinded. In any rigorous study, the scientists that are recording the outcome of the results should be blinded to whether what they're looking for is in the intervention or in the **control group**. This can introduce significant subconscious researcher bias into the results.

- This does not only hold for studies with human subjects. Even when measuring inanimate objects, the person doing the measuring needs to be blinded to the status of what they're measuring.

- Experimental studies generally should be blinded in order to be reliable. Observational studies, on the other hand, can only be partially blinded. The bias of the researcher can influence the results; they will tend to get the results they expect. Often, erroneous results disappear when proper blinding is put into place.

- In a controlled study, you can also ask whether the controls are adequate. What is the subject of the study being compared to? Is the control treatment, for example, in a medical study truly inactive? If you're using an active control, then that may obscure the comparison to the treatment, or the placebo may cause a negative outcome, making the experimental treatment seem artificially better. Perhaps the standard treatment to which a new treatment is being compared may be ineffective, making the new treatment seem more effective than it really is.

- You can also ask whether the control group being studied is representative of the population that you're interested in.

Examining the Literature

- Individual studies can be preliminary and flawed, or they can be rigorous and methodologically sound, but either way, it's still a single study. Very few studies are so large, rigorous, and unambiguous in outcome that they can stand alone and can be considered definitive studies. You always have to put individual studies into the context of the overall research, or the published literature.

- Therefore, the first thing to consider when evaluating an individual study is whether the study has been replicated by independent labs and researchers. If so, is there a consistency to the results, or are the results mixed? In addition, did the results look at the same thing and control for the same variables?

- When looking at any research question—whether a toxin presents a risk factor for a disease or whether a treatment works and is safe,

for example—you have to look at all of the literature and put it into context.

- One feature of the literature that needs to be taken into consideration is called publication bias, or the tendency for researchers to make more of an effort to publish their study results when the results are interesting, positive, and good for their career and reputation and for journal editors to have a bias toward publishing positive studies—the kind that will get good press releases and draw attention to their journal—as opposed to negative results, which are less interesting.

- As a result, it may take many years for any specific research question to mature and advance to the point where we're seeing reliable results. What we really expect to see in the literature are many small, preliminary studies with a large bias toward being falsely positive. Then, as more rigorous studies are conducted, they begin to show the real effect.

- Effect sizes tend to shrink over time as better studies are conducted. Even when the effect is real, the effect size tends to be small in the more rigorous studies. For nonexistent phenomena, the effect size shrinks to zero.

- One type of analysis that looks at many different studies that are addressing similar questions is called a **meta-analysis**, which combines the results of multiple studies into a new statistical analysis. This is a way of obtaining greater statistical power.

- However, the meta-analysis introduces new possibilities for bias. If the preliminary studies were poorly designed and biased, the meta-analysis will still reflect the bias of those preliminary studies. In fact, a meta-analysis is a poor predictor of the outcome of later large, definitive studies.

- Another type of review called **systematic reviews** look at all the evidence and consider the quality of each study, looking for patterns

in the literature, consistency, replication, and relation to effect size and study quality.

- While systematic reviews are a great way to look at the evidence in the literature, they are also subject to bias. For example, which studies do you include in your systematic review? What methods do you use to find studies to include in the review? What were your inclusion criteria? All of these are choices made by researchers that can affect the outcome of the systematic review.

Important Terms

blinding: In scientific studies, this refers to the process of hiding the status of a subject (whether they are in the intervention or the control group) from the subject (single blind) or also from the experimenter (double blind).

control group: In an experimental study, the control group receives a sham or placebo intervention that is physiologically inert so that it can be compared to the treatment group.

experimental study: Scientific studies that involve a specific intervention performed by the experimenters.

meta-analysis: A mathematical process of combining the results of many studies into a single study for statistical analysis.

observational study: Scientific studies in which the behavior of groups are observed in the real world—without experimenter intervention.

prospective study: A study that involves selecting subjects and then following them to observe their future outcome.

P value: A statistical term referring to the probability that the results of a study would be what they are or greater given the null hypothesis—that the proposed phenomenon being studied is not true.

retrospective study: A study in which subjects are selected, and then data is gathered about their history.

statistical significance: A statistical term referring to the comparison of target and control groups in scientific studies; when the difference in outcome or a particular feature is greater than a predetermined threshold, then the results are considered to be statistically significant.

systematic review: A review and analysis of all the relevant scientific studies published on a specific question.

Suggested Reading

Johnson, *The Ghost Map.*

Novella, "Evidence in Medicine: Correlation and Causation."

———, "Evidence in Medicine: Experimental Studies."

Taper and Lele, *The Nature of Scientific Evidence.*

Questions to Consider

1. What are the strengths and weaknesses of experimental versus observational studies?

2. What factors are most important to consider when evaluating a scientific study—or the literature as a whole—on a specific question?

Great Scientific Blunders

Lecture 16

This lecture will cover some of the greatest mistakes and blunders in the history of science, but it will also show how useful it can be to be wrong. The scientists involved in each case made major cognitive blunders; they either were controlled by their own biases or failed to question themselves. These cases demonstrate clearly why initial skepticism is the best response to any new claims. You will also see, in the lessons we derive from these examples, many of the principles of critical thinking that have been presented throughout this course.

René Blondlot: N-Rays

- René Blondlot was a French physicist who in 1903, shortly after the discovery of X-rays by Wilhelm Conrad Röntgen, claimed to have discovered another form of radiation he called **N-rays**, which he believed were emitted by most materials.

- N-rays, however, were invisible. They could only be detected by refracting the N-rays through an aluminum-coated prism, which would then cause a thread coated with calcium sulfide to glow slightly. Reports vary, but about 30 research teams replicated Blondlot's experiments and saw the glowing in the thread. There were about 300 papers total published about N-rays that involved over 100 different researchers.

- However, many prominent labs were unable to replicate the results. In addition, N-rays appeared to have seemingly impossible characteristics. The inability to see N-rays was often explained by believers as the scientists not having sensitive enough vision. Alleged photographic evidence was also plagued with sources of error, such as fluctuations in exposure time.

- In 1903, Johns Hopkins physician Robert W. Wood was sent to do a first-hand investigation of Blondlot's labs and results. Wood

had experience not only as a scientist, but as a skeptic. In the lab, he witnessed several experiments but could not see the effects of N-rays that were claimed.

- In one experiment, he used his hand to block the path of the N-rays, but this could not be detected by the experimenters. In another, he removed the prism needed to refract the N-rays, and in yet another, he replaced the N-ray source with a similarly shaped inert piece of wood. These practices were unknown to the experimenters, and each time, the change was not detected.

- In retrospect, we know that N-rays do not exist and that the researchers were engaged in **self-deception**. They relied on subjected outcomes at the very edge of human detection and on very highly error-prone measurements to establish an entirely new phenomenon.

- N-ray researchers were insufficiently skeptical of their own results. They used special pleading to dismiss the negative results of other researchers, and they did not use proper blinding to eliminate the effects of their own biases.

Jacques Benveniste: Homeopathic Dilution

- In 1988, researcher Jacques Benveniste thought he had discovered proof that homeopathic dilutions—diluting a substance beyond the point where any original ingredient remains—could still retain the chemical properties of what was being diluted.

- Specifically, he was studying the triggering of activity in immune cells in response to an allergic trigger. Benveniste found that the cells would react even to homeopathic doses of the substance, meaning that there was absolutely nothing left—something that all of chemistry and biology says should be impossible. The results were dependent upon observations of a variable biological system, so they could not be replicated in many labs, although some labs did report replication.

- When Benveniste's claims were met with skepticism, he claimed that he was the victim of closed mindedness—that he was being persecuted for challenging the scientific dogma of the day.

- Benveniste also invented fanciful explanations for how the diluted solutions worked: The antibodies communicated their effects to the immune cells remotely through radio waves, and perhaps water acted as a template to remember these signals and give them off later. This even led him to believe that he could record these effects and transmit them over the phone or the Internet.

- However, he never tested or tried to demonstrate these assumptions. He could have designed fairly objective experiments to show if these radio waves existed, but he chose instead to stick with a much more tricky, variable biological system in order to support his claim.

Stanley Pons and Martin Fleischmann: Cold Fusion

- In 1989, Stanley Pons and Martin Fleischmann called a press conference in which they announced that they had experimentally produced **cold fusion**. If true, the announcement could mean a Nobel Prize for these researchers. It could also mean a revolution in energy production—an end to dependence on fossil fuels and a supply of endless cheap, clean energy.

- Existing nuclear power plants use the process of nuclear fission to make heat, which they then use to turn a turbine and generate electricity. Fission is the process of splitting apart heavy radioactive elements, such as uranium. Fusion is the process of combining light elements into slightly heavier elements, such as fusing hydrogen into helium. However, tremendous temperatures and pressures are required to get atoms to fuse together. We can create nuclear fusion for hydrogen bombs, but we don't have the technology to control fusion sufficiently to use it for energy production.

- Cold fusion, as the name implies, is fusion of light elements into heavier elements at low temperatures. Cold fusion would be ideal

for energy production, but we currently do not know how to accomplish this. Many researchers have tried to make cold fusion happen in their labs, but no experimental design so far has been reproducible. Often, the claims are based upon measuring excess energy in an experimental setup, but there are potentially many sources of energy that is unaccounted for.

- It has been suggested, for example, that Pons and Fleischmann's setup—using electrolysis to induce cold fusion in heavy water—was contaminated with tritium and that this contamination could account for the spikes in energy production that they saw that they claimed were due to cold fusion.

- What followed from the press conference in March of 1989 has been referred to as the fusion confusion. After initial excitement, by the end of April of 1989, the press announced that cold fusion was dead and that Pons and Fleischmann's experiments were an example of pathological science.

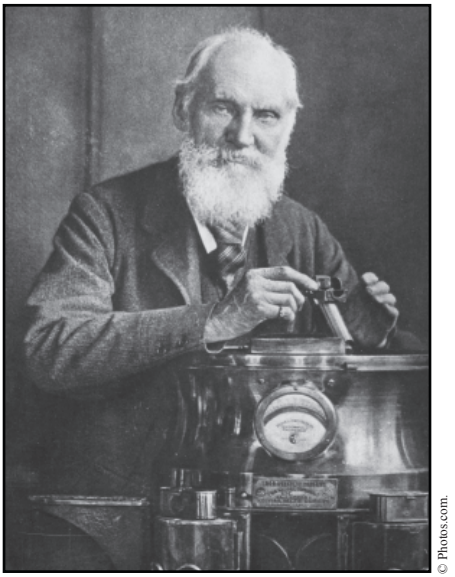
- Pons and Fleischmann appear to have gotten carried away with the excitement of their potential findings. It is far better to allow the wheels of peer review to grind away, to weed out the false hopes, before they become a disastrous embarrassment.

Lord Kelvin: The Age of Earth

- William Thomson, who would later be known as Lord Kelvin (of the Kelvin temperature scale fame), was the most famous physicist of his time. His specialty was thermodynamics, the study of heat.

- Darwin and other contemporaries argued for a very ancient Earth, but Lord Kelvin, who was not impressed by the soft sciences of biology and geology, set out to calculate the age of Earth using the reliable, hard principles of physics. He figured that Earth was cooling, so if it started as an initially molten state, one could calculate how long it would take—using thermodynamic principles—to cool to its current temperature.

- In 1862, he estimated the age of Earth as no greater than 100 million years with a range of 20 million to 400 million years, given the uncertainty in the measurements at the time. He later refined his measurements and reduced his estimate to only 20 million to 40 million years. This did not leave enough time for geological processes to create the Earth that we know today. In fact, Lord Kelvin was highly critical of Charles Darwin and the geologists of his day.



William Thomson (1824–1907), who was known as Lord Kelvin after his death, was a Scottish engineer, mathematician, and physicist.

- Lord Kelvin, while deservedly famous and respected, used his authority to arrogantly push his calculations for the age of Earth. He not only criticized geologists, but he casually dismissed much of contemporary geology, which was simply incompatible with his calculations. He was also hostile in the face of criticism of his calculations.

- However, the deathblow to Lord Kelvin's calculations came with the discovery of radioactivity. Radiometric dating allowed for a highly accurate method of dating Earth, with current results indicating that Earth is approximately 4.55 billion years old.

- There are several lessons to be learned from the story of Lord Kelvin. The first is that scientific authority can never rest in one individual—no matter how famous or successful their career.

- Furthermore, Lord Kelvin was arrogant in dismissing the findings of a scientific discipline of which he was not an expert. He thought he could use physics to casually wipe away all of the carefully accumulated arguments and evidence from geology. This doesn't make him wrong, but it should have tempered his confidence in his conclusion.

- Finally, it would have been more reasonable to conclude from Lord Kelvin's calculations that the inconsistency between the findings of thermodynamics and geology—and also evolutionary biology—meant that there was a piece to the puzzle that was missing, and that piece was radioactivity.

John Edward Mack: Alien Abductions

- In the early 1990s, Harvard psychiatrist John Edward Mack began to investigate patients who reported that they were abducted by aliens. At first, Mack thought they might be suffering from mental illness, but most of his patients did not meet the criteria for a mental illness diagnosis. He then, therefore, began to take their reports much more seriously.

- Mack seemed to have fallen victim to his patients' own beliefs or delusions. He committed the false dichotomy that because his patients were not mentally ill, their reports were credible. He ignored the fact that perfectly healthy individuals can, through flawed thinking and other factors, arrive at firmly held but false beliefs. Additionally, he ignored the fact that there was no corroborating evidence for the stories of his patients, and he engaged in special pleading and the argument from ignorance to justify his conclusions.

Albert Einstein: The Cosmological Constant

- Albert Einstein fell prey to error in what he called the biggest blunder of his career: the incident of the cosmological constant.

- Einstein published his general theory of relativity in 1916. His prior special theory of relativity dealt with the speed of light. The general theory, which was much more complex and difficult for Einstein to work out, also accounted for the effects of mass and gravity.

- Einstein believed, as many others of the time did, in a static universe, but the predictions of general relativity led to the conclusion that the universe must be either expanding or collapsing. Einstein, however, couldn't accept that, so he introduced a fudge factor: the cosmological constant, which is a repulsive force in the universe that would exactly balance the attraction of gravity and make the universe static.

- However, Edwin Hubble later observed the redshift of galaxies, indicating that they are all moving away from us, and published his findings in 1929. Essentially, the universe is expanding, and Einstein was wrong.

- Einstein's blunder was in introducing a fudge factor to rig his results and comply with his preconceptions, rather than seeing an anomaly pointing to a new fact about the universe.

- Ironically, in the 1990s, the concept of a cosmological constant was resurrected to account for the observation that the universe is not only expanding but accelerating. However, this does not rescue Einstein from his blunder.

Important Terms

cold fusion: A hypothetical technique that causes nuclear fusion to occur at relatively low temperatures, especially in a way that would be practical for energy production.

N-rays: A hypothetical type of radiation that was allegedly discovered by René Blondlot but that was eventually exposed as illusory.

self-deception: The act of deceiving oneself due to a host of perceptual, cognitive, and memory biases and flaws.

Suggested Reading

Ashmore, "The Theatre of the Blind."

Burchfield, *Lord Kelvin and the Age of the Earth.*

Youngson, *Scientific Blunders.*

Questions to Consider

1. What failing of critical thinking is common to those scientists who commit epic blunders?

2. What lessons do historical scientific blunders teach us about the limits of authority and the need for replication in science?

Science versus Pseudoscience

Lecture 17

Pseudoscience is a term often applied to science that is so fatally flawed that it lacks sufficient quality to even be considered legitimate science; however, there is often not a clean line of demarcation between legitimate science and pseudoscience. Many claims and beliefs label themselves as scientific, but are they? For example, is anthropogenic global warming a legitimate science or pseudoscience? What about cryptozoology, the study of unusual creatures unknown to current science, such as Bigfoot? This lecture will cover the features that characterize pseudoscience, which also serves as a list of behaviors that good science should endeavor to avoid.

What Is Pseudoscience?

- It is common to claim that one's beliefs are based upon legitimate science. The mantle of good science is often used to market products and promote ideas while the counterclaim that a belief is pseudoscience is equally used to denigrate beliefs and practices that one does not hold. Science still carries a high degree of respect in our society.

- The term pseudoscience refers to beliefs and practices that claim to be scientific but lack the true method and essence of science. They have the patina of legitimate science, but something has gone terribly wrong. Pseudoscience goes beyond just making a few errors or sloppy practices; the methods are so flawed that the entire endeavor is suspicious.

- In reality, there is not a clean division between pristine science and rank pseudoscience. There is, rather, a continuum or spectrum between these two extremes. Many legitimate sciences may incorporate one or more features normally associated with pseudoscience, and some pseudosciences may occasionally make a valid point.

- Between these two extremes of science and pseudoscience, there is a gray zone. This gray zone does not mean that these two extremes do not exist; we can still identify sciences that are mostly legitimate and practices that are hopelessly pseudoscientific. The key is to know how to recognize the features of pseudoscience and of legitimate science.

- Examining extreme cases of pseudoscience is like a doctor studying an advanced form of a disease: The features will be much more obvious and extreme, but they will help the doctor to recognize the more subtle signs and milder forms of the pathology.

- In the same way, we can study these extreme pseudosciences to develop a picture of what pathological features they have in common. Then, we can recognize more subtle forms even in legitimate science.

Features of Pseudoscience

- The most prominent feature of pseudoscience is that it tends to work backward from desired results, rather than following logic and evidence wherever it leads. This is also referred to as motivated reasoning. If we know where we want to get cognitively, human beings are good at backfilling in justifications, making evidence fit into preconceived notions.

- This is why it is so important to be one's own most dedicated skeptic. Legitimate scientists endeavor to disprove their own theories and only give provisional assent once a theory has survived dedicated attempts at proving it wrong. They also consider alternate theories—not just their own theory. Otherwise, they would fall prey to the congruence bias, or only testing one's own theory by looking for positive evidence but not testing alternatives that might also explain the evidence.

- Pseudoscientists, in fact, endeavor to prove their theory correct. They will only look for confirming evidence and will avoid disconfirming evidence. They may engage in special pleading and

try to shift the burden of proof onto others. However, proving their theory wrong—or at least attempting sincerely to do so—should be their job.

- Pseudoscientists also commonly fall prey to confirmation bias, which is the process of looking for supportive evidence that leads to conclusions we wish to be true. This leads to choosing only the evidence that supports one's own theory—favoring positive evidence, regardless of quality, to negative evidence, regardless of quality.

- There is also a tendency to rely upon anecdotal evidence and testimony. Anecdotes are uncontrolled, or ad-hoc observations. They are not systematic; they are, therefore, plagued with confirmation bias and recall bias. Pseudoscientists will often heavily rely upon this type of evidence because, essentially, they could make it say whatever they want it to say.

- Favoring such low-grade evidence over more rigorous evidence because it gives the desired results can be used to support just about any belief—no matter how implausible it is. Emotional appeal is also a common tactic among pseudoscientists who are trying to defend positions that the numbers do not support.

- Additionally, core principles of a particular area of pseudoscience may be based upon a single case or observation rather than a large body of carefully collected data. They use preliminary evidence, or even a single anecdote, as a basis for an elaborate system of belief. They are essentially making the hasty generalization logical fallacy by basing far-reaching principles on a single piece of, perhaps, unreliable or flimsy evidence.

- For example, D. D. Palmer based the principles of subluxation theory on a single case of an alleged curing of a person of deafness with neck manipulation. He then extrapolated from this chiropractic theory. Furthermore, the founder of iridology based the notion that

the iris of the eyes reflects health and disease of the whole body on the observation of a single owl and its broken wing.

- Principles may not be based on just a single observation but on a philosophical idea, a philosophy that itself has not been empirically tested or developed as a scientific theory or discipline.

- The notion of life energy, for example, is a prescientific idea, but it forms the basis of many so-called alternative therapies, such as therapeutic touch, acupuncture, straight chiropractic, and even homeopathy.

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Acupuncture is an alternative therapy that is formed on the basis of the notion of life energy, a prescientific idea.

- Often, pseudoscience involves grandiose claims based on preliminary or flimsy evidence. This is sometimes called the Galileo syndrome for the frequent tendency to compare oneself to Galileo. In other words, far-reaching claims that overturn entire segments of well-established science are extrapolated from very little research or small bits of evidence.

- This tends to occur with pseudoscientific endeavors because when theory conflicts with established science, rather than reassessing one's own theory, the pseudoscientist will simply broaden the implications of their theory, claiming that mainstream science must be wrong because it conflicts with the theory.

- In extreme cases, this leads to what proponents call alternative science, which results from this chain reaction of pseudoscientific

claims. In the end, you have replaced all of science with an alternative version of reality.

- Another example is the comic book artist Neal Adams, who is a proponent of the idea of a hollow, growing Earth. This is the notion that Earth was much smaller in the historical past and has been slowly getting larger over time by the generation of new matter. He believes this is true because the continents of Earth fit together like puzzle pieces.

- When Adams's ideas run up against laws of physics, he just rewrites them ad hoc. For example, he has replaced gravity with magnetism as the force that holds planets in place. He has added the spontaneous creation of matter from nothing. He has even rewritten all of modern geology—from tectonics to volcanism.

- Pseudoscientists are also known for making very bold claims that are often absolute. The bottom line is that they go way beyond the evidence. It's OK to make grandiose claims as long as you have the evidence to back them up, and even modest claims could be pseudoscientific if they extend too far beyond what the evidence can meaningfully support.

- Good science, rather, is very careful and conservative. It tends not to make claims that exceed the evidence; it tends to be understated if anything. For example, in the process of peer review, when experts in a field review a paper submitted by one of their colleagues in the hopes of being published, one of the specific things they have to decide is whether the conclusions of the researcher extend from the evidence. If the authors are making conclusions that go beyond the evidence, they will often be required to fix that before the paper can be accepted for publication.

- Another aspect of pseudoscience is that simple answers are often offered to complex questions. While scientific progress often leads to simple or elegant solutions, pseudoscientists offer simplistic solutions even to very complex phenomena.

- For example, we often call these a theory of everything. Scientists are legitimately looking for increasingly powerful and elegant theories that can explain more of the natural world, but when that process is taken to an extreme—where one small phenomenon is used to explain our entire understanding of the universe—then that becomes a theory that is exceeding the justification.

- Pseudoscientists also often demonstrate hostility toward scientific criticism. In the process of peer review, in which a community of scientists is essentially highly critical of any new claims that are made, scientists try to tear scientific theories apart. It's the only way to separate those ideas that are useful and have potential from those that are a dead end.

- While nobody likes to be criticized, scientists have to develop a thick skin because criticism is part of the process of science. Pseudoscientists, however, generally cannot accept mainstream harsh criticism. As a result, they often do not engage with the scientific community. They claim that they are the victim of a conspiracy or a dedicated campaign against their ideas—perhaps because their ideas are simply too revolutionary.

- Pseudoscientists may appeal to antielitist sentiments. As part of their antielitism, they may try to make a virtue of their own lack of education, training, or experience. They make claims that knowledge puts blinders on mainstream scientists and that only they have the vision to see things the way they truly are.

- Pseudoscientists also use scientific-sounding terms to impress others but lack scientific precision. Scientific jargon exists for a reason: to have precisely and unambiguously defined ideas. However, pseudoscientists use words to obfuscate. They use terms that are often vaguely defined or have a shifting meaning.

- For example, proponents of intelligent design often imprecisely use the term "information" by shifting meaning at different times without ever using a precise definition. They get tangled in their

own confusion. Another common example is the vague use of the term "energy."

- Pseudosciences are also marked by a failure to progress. Sciences that are legitimate and useful tend to progress over time whereas pseudosciences tend to be stagnant. Pseudosciences are chasing their tail or are endlessly trying to establish their basic principles or the very existence of the phenomenon that they are studying, but they do not build a body of evidence.

- Research surrounding ESP is the best example, in which pseudoscientists are still searching for a reproducible research paradigm. As one paradigm fails, they just continue onto the next paradigm with nothing to show for it in the long term.

- Anomaly hunting is another feature that is common to pseudosciences. Anomalies are very usual in science because they point to a shortage or hole in our current understanding, but looking for anomalies as a way of establishing a conclusion is called anomaly hunting, which does not seek to falsify or explore alternatives.

Suggested Reading

Gardner, *Science.*

Novella, "Anomaly Hunting."

———, "Anatomy of Pseudoscience."

———, "Ghost Hunting Science versus Pseudoscience."

Pigliucci, *Nonsense on Stilts.*

Randi, *Flim-Flam!*

Schick, Jr. and Vaughn, *How to Think about Weird Things.*

Shermer, *The Borderlands of Science.*

Questions to Consider

1. What feature most characterizes pseudoscience?

2. How does studying pseudoscience help the practice of legitimate science?

The Many Kinds of Pseudoscience

Lecture 18

In the previous lecture, you learned the difference between legitimate science and flawed pseudoscience. In this lecture, several specific examples of pseudosciences will be introduced and then deconstructed to illustrate some of the various features of pseudoscience. Believers in these pseudosciences think they are doing science, but they all have one common flaw: They are insufficiently skeptical of their own claims. They are dazzled by what they think they have discovered and set out to prove their ideas correct—instead of setting out to prove their ideas false.

Iridology as Pseudoscience

- Iridology is a practice that was invented in 1800 by Ignaz von Peczely. He based his entire belief of iridology on a single observation, in which he accidentally broke an owl's leg and noticed a black stripe in the iris of its eye. When the owl's leg later healed, the black speck went away. He concluded from this that the iris is a map of the entire body where the flecks and color reflect the state of health or illness of each different part of an organism's body.

- This belief follows a more general belief known as a homunculus paradigm; many superstitious systems are based on the notion that the entire body is mapped in some way to a smaller subset of the body. There is, however, no scientific basis for this.

- What iridologists do is essentially what is called a medical cold reading, which involves making vague and common guesses about someone—in this case, their symptoms—to give the impression that they have detailed knowledge about their symptoms.

- For example, if you ask your mom if she has any lung disease based on your reading of her iris, and she says that she doesn't, you could say that, therefore, she has susceptibility for lung disease and that it might become a problem in the future.

- A 2000 review by Edzard Ernst of iridology studies that were deemed to be of sufficient quality concluded that they showed no diagnostic ability of iridology. In fact, iridologists perform no better than chance when they are properly blinded.

- However, the practice of iridology persists as an alternative practice. Current practitioners engage in special pleading; believers in iridology successfully isolate their claims from the scientific evidence.

Ghost Hunting as Pseudoscience

- The most common type of evidence that ghosts exist is ghost photographs. These often present what are called **orbs**, which are circles of light on photographic film, or ghost globules, which are streaks or coils. At times, more interesting photos appear to have ghostly figures or people in the frame.

- Ghost hunting is a good example of anomaly hunting. Ghost hunters look for anything unusual and then conclude that it is evidence for ghosts. Therefore, they make the argument from ignorance. They may take the time to dismiss a token alternative or two, but they do not engage in hypothesis testing, which could distinguish a true anomaly from a photographic artifact like globules and streaks. Ghost hunters have no basis for what a ghost photograph should look like, so they can declare any anomaly a ghost.

- There are, however, explanations for the photographs that are presented by ghost hunters. For example, most photos with light effects use a flash. Orbs are known photographic artifacts of lenses. Sometimes light can reflect off of dust motes, which are things that you won't see with the naked eye but that the camera will pick up when a flash reflects off of it.

- Streaks are often the result of the so-called camera cord effect, which could be due to anything that's in front of the lens and very close—especially when a flash is used. Even a black plastic camera

cord, when in front of the lens, will reflect the light and cause a whitish streak across the film.

- Streaks also may be due to unfamiliar settings on digital cameras, such as the twilight mode, which uses a flash but then keeps the shutter open so that camera movement can create streaks.

- Other photographic effects might include an actual image of a ghostly person or figure in the film or on the picture. This is not a streak or a globule, so this can't be a simple artifact. Older cameras often created accidental double exposures. If the film did not advance and a subsequent picture was taken, there could be a ghostly, faint image of a person from one exposure on the other.

- Sometimes the ghostly image is just pareidolia, which may allow you to see what appears to be a distorted ghostly body or face in a foggy or blurry image. It's also possible that a live person was simply in the field of view but wasn't noticed at the time the picture was taken.

- Ghost hunters use scientific instruments to take readings and then declare any apparent anomalous readings as further evidence for ghosts. For example, they are fond of using electromagnetic detectors to look for electromagnetic fields. Typically, they're using off-the-shelf electromagnetic detectors. Most of the ones they use are not directional, and the electromagnetic range is arbitrary.

- In our modern society, electromagnetic fields are everywhere, so finding them in a house is not surprising. Furthermore, ghost hunters do no controlled studies that are designed to determine what the source of the electromagnetic fields is and to rule out mundane explanations.

- Another phenomenon often presented by ghost hunters as evidence for ghost activity is ghost cold, which is a cold spot that is alleged to be the evidence of a ghostly presence. In fact, many houses have

drafts and cold spots—especially older houses, the kind that ghost hunters are fond of investigating.

- Despite the fact that nobody has been able to produce any reliable, compelling evidence that ghosts are a real phenomenon, people do have many ghostly or anomalous experiences. Of course, we are not dismissing that people have these experiences; the question is how best to interpret them.

- There's ample evidence that these experiences result from errors in perception followed by pattern recognition, hyperactive agency detection, and simple errors in memory. Often, ghost encounters occur under poor observing conditions. They may occur when people are sleep deprived or when anxiety or expectation levels are very high.

Free Energy as Pseudoscience

- Of course, it would be great if we could find a clean, renewable, cheap, abundant, and efficient source of energy. Our civilization would be greatly enhanced by this because our civilization runs on energy. Currently, much of that is fossil fuel because fossil fuels are cheap, abundant, and efficient, but they are not clean or renewable.

- The strong need and desire for cheap energy leads to a lot of energy pseudoscience. The most extreme versions are often referred to as **free energy** because they promise not just abundant but limitless energy.

- A common version of free energy is a motor that generates more power than it consumes. These motors are called **overunity** machines because they produce more energy than they consume. Usually, these are demonstrated on a small scale with a claim that they are able to scale up. However, at small scales, it's easy to miss a small energy source and confuse that with anomalous energy production.

- Ultimately, such devices never work. They don't scale up because they can't generate free energy. Often, however, there are deliberate scams; there are companies that claim to be on the verge of a breakthrough in free-energy machines to trick investors into sinking lots of money into their invention.

- Many of these devices use magnets and neglect the fact that the magnets themselves are providing a finite source of energy to the process. Believers of these machines do not try to prove their claims wrong; rather, they are looking for proof of their claims.

- The most significant scientific problem with free-energy claims is that they violate the first and second laws of thermodynamics—that energy can change form but cannot be created out of nothing and that in any thermodynamic process, some energy will be lost, respectively.

Psi Phenomena as Pseudoscience

- Psychic abilities, which involve the ability to read other people's minds, are sometimes called extrasensory perception or anomalous cognition. Other forms include precognition, the ability to perceive things before they happen, or remote viewing, the ability to perceive things that are remote from your location.

- These various phenomena have been actively researched over the last century; however, the plausibility is extremely low. Even if we put the plausibility issue aside, researchers have not been able to convincingly show that **psi phenomena** exist.

- In the past, psi researchers produced some classic examples of pseudoscientific methods. One such phenomenon is called psi missing, which is the notion that sometimes those with ESP may guess the incorrect answer more often than would be predicted by chance.

- Another example is optional starting and stopping, which is the notion that some individuals with ESP may require a warm-up

period before their abilities begin and that their abilities may fatigue and suddenly stop working.

- Both of these are excellent examples of inadvertent mining of the data, or looking for and counting only those data points that are positive and eliminating the negative data points.

- Psi missing and optional starting and stopping come from a flawed sense of probability; they ignore the fact that in any random sequence there will be runs of hits and misses that will occur by chance alone.

People who have ESP, or extrasensory perception, claim that they have psychic abilities that involve reading other people's minds.

- Reproducibility is key in science because any single study can be a fluke. Publication bias—the tendency to publish positive studies, not negative ones—often occurs so that fluke positive studies can be chosen among many unpublished negative studies. If an effect is real, it should be consistently reproduced.

- The key flaw in the psi literature is this failure of reproducibility. Initial impressive results tend to diminish over time as tighter controls are introduced and when protocols are replicated. This is generally seen in science and is known as the decline effect, in which effect sizes tend to diminish with replication. Real effects will persist while illusory effects will vanish.

- Some ESP researchers have claims that psi effects truly decline over time, but this is just another form of special pleading, or making up an excuse because of lack of evidence or problems with a theory.

Spontaneous Human Combustion as Pseudoscience

- Spontaneous human combustion is the notion that people can spontaneously burst into flames and be consumed by the resulting fire. This is based almost entirely on unusual cases of death by fire. The idea of spontaneous human combustion combines anomaly hunting with argument from ignorance.

- Most of the cases of spontaneous human combustion have an easily identifiable external source of flame. Victims are often infirmed, are on sedating medication, live alone, and are smokers.

- Researchers have explained even the strangest cases by the wick effect, in which the body can act like a candle with the clothes acting as a wick. However, with so many fires, we would expect the occasional unusual case. There are no plausible or known mechanisms for spontaneous human combustion.

Important Terms

free energy: The general term for any alleged process that produces energy without burning fuel or other limited resource.

orb: The name given by ghost researchers to a sphere of light that is seen on film and believed to be evidence of ghosts but is more easily explained as a photographic artifact.

overunity: A process that generates more energy than it consumes, in violation of the laws of thermodynamics.

psi phenomena: Alleged phenomena dealing with extrasensory perception—also called anomalous cognition—such as mind reading, remote viewing, and precognition.

Suggested Reading

Gardner, *Fads and Fallacies in the Name of Science.*

Nickell, "Ghost Hunters."

Novella, "Bem's Psi Research."

———, "Spontaneous Human Combustion."

———, "The Decline Effect."

Polidoro, *Secrets of the Psychics.*

Stenger, "The Phantom of Free Energy."

Questions to Consider

1. How do claims of free energy violate well-established laws of physics?

2. What features of psi research are cause for skepticism?

The Trap of Grand Conspiracy Thinking

Lecture 19

It seems that humans have an inherent tendency for conspiracy thinking—although some have more of a tendency than others. However, we shouldn't think that conspiracy thinking is restricted to a few crazy people. Keeping on the lookout for genuine conspiracies is important, which is partly why conspiracy thinking persists. By examining extreme conspiracy theories, we hope to identify those patterns of thought and cognitive traps that we all fall into to a lesser degree. Being familiar with grand conspiracies will also help us identify more subtle flaws in our day-to-day reasoning.

Conspiracy Thinking

- To some extent, we all have a little conspiracy theorist inside each of us; the notion that dark and powerful forces are working against our interest grips our attention and can seem very compelling.

- This is, in fact, an adaptive trait, such as anxiety, for example. It is useful in moderate amounts but is counterproductive and even debilitating when extreme. While there are certainly conspiracies in the world, conspiracy thinking can be a cognitive trap that is easy to fall into but very difficult to get out of.

- A conspiracy occurs when two or more people conspire together to engage in some secret or nefarious purpose. Grand conspiracies, however, are large conspiracies that involve many people across multiple organizations acting for long periods of time.

- **Grand conspiracy** theories tend to divide the world into three groups. The conspirators are a vastly powerful organization with incredible resources and evil intentions—up to and including taking over the world. They also, however, make simple mistakes or are incredibly careless because otherwise, nobody would know that they exist.

- The second group is the conspiracy theorists. They have the ability, in their own view, to see the conspiracy for what it is. They can read between the lines and recognize the hand of the conspirators at work. They often envision themselves as being part of an army of light whose goal is to save the world from the dark conspiracy.

- Everyone else in the world falls into the third group, which are the naive dupes—the people who are not engaged in the conspiracy and don't see that it exists.

- A classic example of a grand conspiracy theory is the belief in the Illuminati, which are alleged to be a shadow world government. Their goal is to bring about a new world order in which they rule and control the entire world.

- Conspiracy theorists see the Illuminati behind everything that happens in the world. According to conspiracy theorists, they reveal themselves through symbolism. For example, the seal on the U.S. dollar is the all-seeing eye that they claim is a symbol of the Freemasons, who are supposedly connected to the Illuminati.

- Conspiracy thinking is a way to make sense of complex or mysterious events. More likely, conspiracy thinking occurs when people feel that they lack control or are being victimized.

- In fact, we often lack detailed information about important political events or other events, and this opens the door even further to conspiracy

Innocent symbolism, such as the all-seeing eye on the back of the U.S. dollar bill, is evidence of the Illuminati to conspiracy theorists.

thinking because we can fill the gaps in our knowledge with ideas or notions that are comforting in some way. Conspiracy thinking offers the illusion of certainty—much like superstitions provide an illusion of control.

Conspiracy Thinking and Pattern Recognition

- Conspiracy theories are a form of pattern recognition. A conspiracy theory is a pattern imposed upon disconnected events. Conspiracy thinking is the cognitive form of pareidolia. Essentially, conspiracy theorists connect the imagined dots between disconnected events and see an invisible hand operating behind the scenes.

- Pattern recognition is also more common in response to feelings of powerlessness. Conspiracy thinking potentially meets other psychological needs as well, such as self-esteem, which may be a reaction to an inability to attain one's goals.

- Being part of an army of light, for example, offers not only self-esteem, but also a way to channel feelings of anger. It makes people feel as if they are part of a privileged, enlightened few—a notion that fits with the psychology of belief.

- There is a struggle happening in our brains between two inherent tendencies: reality testing and pattern recognition. Conspiracy thinking, a form of pattern recognition, is filtered through the reality-testing module in our brains. We see an apparent pattern, and then we ask ourselves whether the pattern makes sense and whether it conforms to our internal model of reality.

- People vary in terms of the strength of their pattern recognition and reality testing. For example, the psychiatric disease known as schizophrenia is understood largely as a condition marked by diminished reality testing.

Cognitive Traps of Conspiracy Thinking

- There are various cognitive traps that conspiracy thinking falls into. One is confirmation bias, which involves the tendency to see all

evidence as confirming the conspiracy. Any bit of evidence can be cast in a sinister light. Therefore, ambiguous and even negative evidence tends to reinforce the conspiracy theorists' certainty and confidence in their conspiracy after awhile. This is a self-reinforcing effect that makes conspiracy theorists incredibly resistant to change.

- Conspiracy theorists often commit to what is called the fundamental attribution error, which is the tendency to blame other people's behavior on internal, rather than situational, factors. Conspiracy theorists tend to think that all actions and outcomes are deliberate and intended. They ignore or downplay the quirky nature of history and of individual action, refusing to believe that people may be innocently responding to a situation rather than deliberately orchestrating every detail. For these reasons and others, the conspiracy theory tends to become immune to refutation.

- The biggest cognitive problem with conspiracy thinking is that it quickly becomes a closed belief system, which is a belief system that contains the mechanisms of its own insulation from external refutation from facts and evidence. All evidence against the conspiracy can be explained as being part of the conspiracy itself.

- For example, any evidence that links Lee Harvey Oswald to the John F. Kennedy assassination could be seen as having been planted in order to frame Oswald, including the gun that he used, the bullet that was recovered, and the picture of Oswald training with the gun before the assassination.

- Furthermore, any evidence that is lacking for the conspiracy can be explained as having been removed or covered up by the conspirators. Therefore, conspiracy theorists can explain the existence of any disconfirming evidence and the lack of any evidence for their preferred conspiracy theory. They render themselves immune to any possible refutation.

- They also render themselves immune to any burden of proof. They frequently attempt to shift the burden of proof onto those who do

not accept their theories. They challenge others to prove that their conspiracy is not true when they have the burden of providing evidence that it is.

- They combine the shifting of the burden of proof with the moving goalpost. No matter how much evidence is provided in support of a nonconspiracy interpretation of events, it is never enough. For example, unless every quirky detail of the events of 9/11 can be explained to an arbitrary level of detail, conspiracy theorists will claim that there are still holes in the standard explanation.

- Conspiracy theorists engage, like many pseudoscientists, in anomaly hunting. If you take any complex historical event—such as the John F. Kennedy assassination or 9/11—there will be many anomalous details, or events that cannot be fully explained. This is because of the law of large numbers—the fact that the number of variables is so high that quirky events and strange coincidences are bound to happen. Plus, we cannot know all the situational factors that may have contributed to how events occurred.

- Conspiracy theorists often combine anomaly hunting with naive assumptions about how things should happen. For example, what should the debris field look like after a large commercial jet crashes into a reinforced building, such as the Pentagon?

- It is naive to assume that we can know with any detail what would result; such an event is unprecedented, and the physics of high-energy impacts are not always intuitive. However, 9/11 conspiracy theorists premise their claims on the notion that they can know what it should look like, and therefore, anything that does not fit their assumptions is an anomaly and evidence that the standard explanation is flawed.

- To complete this chain of reasoning, the conspiracy theorist proposes a false dichotomy—that either the standard explanation of events is true or their conspiracy is true. Therefore, if they can knock holes in the standard story and call it into doubt, through

naive anomaly hunting, then their conspiracy must be true. Of course, anomaly hunting is not persuasive. Additionally, there are other possibilities, so they are offering a false choice.

- Another cognitive trap that conspiracy theorists fall into is widening the conspiracy. This is another mechanism by which to render a conspiracy immune to contradictory evidence.

- The greatest weakness of grand conspiracies is that they tend to grow, involving more people in order to answer problematic questions. Additionally, the power and resources attributed to the conspirators grow until it seems there is almost nothing they cannot do.

- Eventually, they simply collapse under their own weight. If the United States never really landed astronauts on the moon, then why didn't the Soviet Union call us on it? They certainly could have tracked our rockets. Were they in on it? The number of people and organizations that would need to be involved becomes too great to plausibly maintain coordination and secrecy.

What's the Harm of Conspiracy Thinking?

- There is some debate as to whether the existence of conspiracy theories is a net positive or negative. On the positive side, conspiracy theories do serve the purpose of challenging the powers that be. They showcase deficiencies in the sometimes-inadequate explanations the members of the government give for their actions. Conspiracy theories further promote the need for transparency and full disclosure.

- On the other hand, conspiracy theories tend to erode confidence in government and democracy. Some argue they may even hurt the cause of transparency; the existence of absurd and implausible conspiracy theories can be used to dismiss any questioning of conventional explanations.

- Reasonable questions or attempts at keeping governments or corporations accountable can be lumped in with the lunatic fringe of crazy conspiracy theories. Some conspiracy theorists have even hypothesized that the government is responsible for some of the worst conspiracy theories in order to delegitimize any questioning of the official version of events.

- In addition, conspiracy theories often have a very simplistic or one-dimensional approach to complex problems. They are sometimes often framed in very racist or bigoted terms. The conspirators may be, for example, an ethnic group. This both results from and reinforces the underlying racism.

- Whether it's harmful or not, conspiracy thinking is a type of pseudoscience that demonstrates many of the principles discussed in earlier lectures. They meet many psychological needs. They are built on cognitive biases and are maintained with logical fallacies. They are further fueled by errors in perception and memory. The entire process is fatally flawed because of circular reasoning that immunizes the conspiracy theory from any possibility of refutation.

Important Term

grand conspiracy: A large, far-reaching conspiracy often alleged to span multiple organizations, people, and even generations.

Suggested Reading

Goertzel, "The Conspiracy Meme."

Klass, *The Real Roswell Crashed Saucer Coverup.*

Novella, "Conspiracy Thinking."

Posner, *Case Closed*.

Questions to Consider

1. How do conspiracy theorists render their beliefs immune to refutation?

2. What role does anomaly hunting play in generating and supporting conspiracy theories?

Denialism—Rejecting Science and History

Lecture 20

Denialism is a subtype of pseudoscience that seeks mainly to deny an established science rather than promote a dubious claim. Deniers violate multiple principles of critical thinking, logic, and scientific methodology because of their a priori beliefs. By studying the tactics of deniers, we learn to recognize the more subtle versions that you engage in every day. Generally, we resist changing our beliefs, and a little bit of motivated denial can save us from a lot of cognitive dissonance—unless we deliberately engage our learned critical thinking skills.

Denialism as Pseudoscientific Thinking

- Just as with grand conspiracy thinking, **denialism** is a category of pseudoscientific thinking worthy of separate consideration. This is not to say that the conventional wisdom on any topic is always correct or is beyond error. However, there is often a commonality among the various forms of denial; the same cognitive and logical errors are being committed.

- Like any pseudoscientific thinking, denialism begins with a desired conclusion. Rather than supporting a controversial or rejected claim like many pseudosciences, denialists maintain that a generally accepted scientific or historical claim is not true—usually for ideological reasons. Denialists then engage in what is called motivated reasoning, or rationalizing why the undesired claim is not true or at least not proven.

- They, therefore, are working backward from their desired conclusion, filling in justifications for what they believe rather than following logic and evidence wherever it leads.

- Denialism has the same problem that we described previously with pseudoscience in general: the **demarcation problem**, or the line between denialism and healthy skepticism. There is a continuum

between the two extremes with a gray zone in between, but also like pseudoscience, there are a number of behaviors that characterize denialism.

- Of course, everyone thinks that they are true skeptics—skeptical to just the right degree. Anyone who believes something they do not must therefore be a true believer, and anyone who rejects a belief they accept must be a denier. It's natural to use ourselves as the anchoring point for true scientific skepticism. Therefore, deniers often portray themselves as skeptics and even use the term.

Strategies of Denial

- The primary cognitive flaw that marks a belief system or behavior as denialism is moving the goalpost, or always demanding more evidence for a claim than is currently available. When that burden of evidence is met, then the goalpost is moved back further and even more evidence is demanded. As an example, those who engage in evolution denial, or creationism, often say that there are no transitional forms in the fossil record. They use vagueness in defining the term **transitional fossil** to move the goalpost.

- At first, it seems as if they mean there are no fossils that are intermediary in morphology between two extant species or between a descendent species and its ancestor. When such examples are provided, they then move the goalpost by changing the definition. They then demand evidence that the transitional fossil is not just morphologically intermediate, but that there is separate evidence that it is actually ancestral.

- Related to this is the unreasonable demand for evidence. No science is established down to the tiniest possible detail; there are gaps in our understanding of even the most solid theory. The presence of incomplete knowledge, or gaps in our knowledge, does not necessarily call into question what we do know and what is well established.

- HIV denial is an excellent example of the unreasonable demand for evidence. Deniers often demand to see a single study or paper that establishes that HIV causes AIDS. However, the role of HIV in AIDS is not established by any one piece of evidence but, rather, by a large body of research, each providing one piece to the puzzle. They further claim that HIV does not meet all the Koch criteria for proving that an infectious agent causes a specific disease or syndrome.

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The same cognitive and logical errors are committed among the various forms of denial.

- However, Robert Koch's criteria were formulated prior to the discovery of viruses, so they are better suited to the study of bacteria. Furthermore, we have many tools available today that were not available in the 19th century when Koch developed his criteria.

- If you take a snapshot of any science at any time, there will be gaps in the available knowledge. It is more useful to ask how science is progressing over time. Are the gaps slowly being filled? Is our knowledge deepening? This is a better understanding of science in any case. How successful is a scientific theory in making predictions, leading to further and deeper questions, and fitting together with other lines of evidence?

- For example, we can look at the notion of denialism from the other side by comparing a legitimate science evolution to psi research. Over the last 150 years, evolutionary theory has been remarkably successful. It has tremendous explanatory power in terms of developmental biology, genetics, and paleontology. In

fact, genetics provides powerful independent support for evolution, which in turn helps us make sense of genetics. Furthermore, our understanding of the patterns and mechanisms of evolution has deepened. It is one of the most successful scientific theories ever developed.

- On the other hand, psi research—extrasensory perception—has been going around in circles and not progressing at all. It has yet to develop a single repeatable experimental demonstration of psi. It does not provide any predictive or explanatory power. In addition, it has not gained support from any other field; we have discovered nothing in neuroscience that makes psi more plausible, and psi does not help us understand neuroscience.

- Related to the strategy of pointing to gaps in our knowledge—rather than considering how useful and predictive a theory is—deniers will often point to disagreements within a discipline, often about small details, as if they call into question basic and well-established conclusions. There is always disagreement within a scientific discipline; it doesn't mean the science is not solid.

- For example, historians disagree about the precise number of Jewish people who were exterminated in the concentration camps. Deniers use this disagreement to argue that maybe the number is zero.

- Another strategy of denial is to arbitrarily narrow the kinds of research and evidence that counts as scientific. Deniers, in fact, will often cite the logical fallacy of confusing correlation with causation. While it is true that correlation does not necessarily equal causation, it is evidence that may be due to causation. Therefore, we cannot eliminate all correlation as a form of evidence; we simply need to use it properly. Otherwise, the entire field of **epidemiology**, the study of the incidence and spread of disease, would vanish.

- For decades, the tobacco industry denied the science that establishes that smoking is a significant risk factor for certain kinds of cancer,

especially types of lung cancer. Their primary argument was that the data showing a link was correlational only.

- They acknowledged that smoking correlates with cancer but denied that this was enough to establish causation. Perhaps, they argued, cancer causes smoking, or perhaps some third factor causes both smoking and cancer.

- What they ignored is the fact that different causal hypotheses make different predictions and can be tested. If smoking causes cancer, then statistically, smokers will begin smoking before it is likely that the cancer developed. The duration of smoking will correlate with increased risk, and unfiltered cigarettes will have a higher risk than filtered. Additionally, quitting smoking will reduce cancer risk. All of the predictions are true. In other words, multiple correlations can be used to triangulate to one specific cause and effect—in this case, that smoking causes cancer.

- Evolution deniers use a similar strategy: to deny that any historical science can be truly a science. They argue that because nobody was around when life developed, we cannot know what happened or that because we cannot reproduce evolution in the laboratory, it's not a real science. This denies, however, all historical sciences—including geology, astronomy, and forensics.

- The core property that renders a science legitimate is that it engages in hypothesis testing. Hypotheses make predictions that can be falsified. Those predictions do not have to be tested in a lab, however. They can be predictions about what we will find when we look at nature.

- For example, evolution makes predictions about what we will find when we compare the genetic sequence for various proteins among species, so we can scientifically infer what happened in the past—even if we cannot go there to see it for ourselves.

- If you look hard enough, you can always find facts that, taken out of context, can seem inconsistent with a scientific theory or claim. Pile enough of them together, and you can build a superficial case against any theory.

- For example, Holocaust deniers have pointed out that **Zyklon-B**, a form of cyanide gas, was used at Auschwitz and other camps for delousing. They also point out that the delousing chambers contained much more cyanide residue than the alleged gassing chambers and that some gas-chamber ruins contain no cyanide residue.

- Taken together, these facts may appear to cast doubt on the claim that gas chambers were used to exterminate humans at these camps. All of these claims are true, but they are out of context.

- Zyklon-B was used for delousing objects, but it was also used to kill inmates. Also, humans are much more sensitive to cyanide than lice, and it takes a much smaller concentration to kill humans; therefore, the delousing chambers had a much higher concentration of cyanide. The cyanide residue washed off those walls that were exposed for years to the elements. Walls that were less exposed contain cyanide residue consistent with their use as gas chambers. Additionally, none of this addresses the other lines of evidence for the use of Zyklon-B in gas chambers.

A Campaign of Doubt and Uncertainty

- The goal of denial is to sow doubt and uncertainty. This is done by pointing to apparent inconsistencies—current gaps in knowledge—sometimes to points from legitimate dissent, and also to the messiness of science. Scientists make mistakes all the time by pursuing dead ends, using bad arguments or evidence, and even committing fraud.

- It is, therefore, easy to find ways to call any scientific claim into doubt—if that is your goal. Healthy skepticism, on the other hand, fairly considers all the evidence and puts it into the proper

perspective: critical thinking. It acknowledges that all knowledge is incomplete and that scientists are imperfect people. We can still come to reliable conclusions with sufficient evidence.

- Deniers often combine their program of doubt with false dichotomy. If the accepted version of events is not true, then their alternate claim or version must be true. This, however, is also an argument from ignorance. What they rarely do is provide evidence for their alternate claim.

- The ultimate fallback position for the denier is the conspiracy theory. When the evidence does not support their position, they will often just claim that the scientific evidence itself is all a fraud, a grand conspiracy, usually of their ideological opponents. This allows them to dismiss all the evidence—all the published studies that prove the science they do not want to acknowledge.

Important Terms

demarcation problem: A philosophical term that refers to the difficulty in clearly defining a separation between two ends of a continuum, such as the difference between science and pseudoscience.

denialism: A form of pseudoscience that uses poor logic and distortion of science in order to deny the conclusions or legitimacy of an accepted scientific theory or fact.

epidemiology: The study of the incidence, spread, and associated factors of disease.

transitional fossil: A paleontological term to refer to a fossil specimen that represents a species that lies phylogenetically between two other species or groups.

Zyklon-B: The trade name for a form of cyanide gas that is used for delousing, but it is also infamously used by the Nazis during World War II to exterminate humans.

Suggested Reading

Grant, *Denying Science.*

Novella, "More on God of the Gaps."

———, "Skepticism and Denial."

———, "Scientific Proof and Evolution Denial."

Novella and Smith, "HIV Denial in the Internet Era."

Oreskes, "Merchants of Doubt."

Specter, *Denialism.*

Tokuno, "Holocaust Denial."

Questions to Consider

1. What are the major differences in method between healthy skepticism and denial?

2. How did the tobacco industry use a campaign of doubt to generate confusion about the correlation between tobacco use and lung cancer?

Marketing, Scams, and Urban Legends

Lecture 21

Critical thinking is not just for scientists; it can be applied to our everyday lives. For example, marketing often provides situations in which critical thinking should be exercised. Marketing messages are often deceptive and attempt to exploit human psychology. Scams are another area where critical thinking can provide an important layer of protection. Furthermore, in the age of the Internet, urban legends, chain letters, and rumors can spread virally, making it more important than ever to be able to determine which information is reliable and which is bogus.

Motivated Misinformation

- In one form or another—whether it's **spam**, traditional mail, telemarketing, or mainstream ads—we are bombarded with motivated misinformation trying to manipulate us in some way. Persuasive speech, propaganda, and marketing have probably existed as long as human communication, but we are also living at the dawn of the Internet age—in which every point of view, bias, and agenda can vie for equal access on the web.

- More than ever, therefore, we need basic critical thinking skills to survive in this age of misinformation. In other words, nobody is filtering information for us, so we have to provide our own filters to assess which information out there is reliable and authoritative and which is biased and perhaps even malevolent.

- There are different types of scams. Some are deliberate and malevolent. For example, you might have received something similar to the following e-mail: My associate has helped me to send your first payment of $7,500 to you as instructed by the Malaysian Government and Mr. David Cameron, the United Kingdom prime minister. To claim your $820,000, all you need is a certificate, which you can get by sending me some personal information.

- This type of scam is known as the **Nigerian scam** (also called the 419 scam) because so many of them originate in Nigeria. This type of scam dates back to the 1920s; now, it's a five-billion-dollar-per-year worldwide scam.

- Obviously, like many scams, this type plays on the greed and gullibility of its victims. With e-mail, scammers can scan millions of potential targets, looking for nibbles. If you answer, then they will reel you in as far as they can. First, you will have to pay to get the certificate and then again to bribe a corrupt agent somewhere—it will never end.

- Some scams even try to get you to fly to an airport in another country to collect your cash, but the purpose is to kidnap you and ransom you back to your family.

Urban Legends

- Were 450 girls under 10 years of age forcibly married to men in their 20s in a mass wedding in Gaza in 2009? That's the claim of countless e-mails and blogs.

- This type of scam is more of an urban legend than crafted deception. Although it must have started from someone who knew they were making unwarranted assumptions or maybe even inventing details, it spreads mainly by those who believe the content. The evidence for the claim given is several photographs of the young alleged brides with their older grooms. These e-mails were used to stir up anti-Muslim sentiment.

- There was indeed a mass wedding put on by Hamas in Gaza in 2009. However, the young girls were not the brides; they were young relatives of the grooms—nieces and cousins, as is the tradition. Western reporters present at the wedding confirmed this. In fact, the youngest bride was 16 and most were over 18.

- There are many red flags in these e-mails: The tone is highly political and emotional; no links or authoritative resources are

given; the pictures do not provide any clear context, allowing for misinterpretation; and it seems unlikely that the mainstream media would have missed such a story. None of these factors prove the story false; they should just raise the level of skepticism. Only a few minutes of investigation uncovers the information to put the story into context.

- Sometimes misinformation is not political or ideological but speaks to a common fear in our society. We fear exposure to toxins and chemicals from our highly industrialized society. We trust others to prepare our food. We fear invasion of our borders and the watering down of our values. We fear the intentions of others.

- Those urban legends that spread are often ones that resonate with some fear or anxiety. The classic example of this is the kidney thief. A gentleman away on business gets picked up in the hotel bar by a beautiful woman only to wake up the next morning in a bathtub full of ice with a scar down his back and one of his kidneys missing.

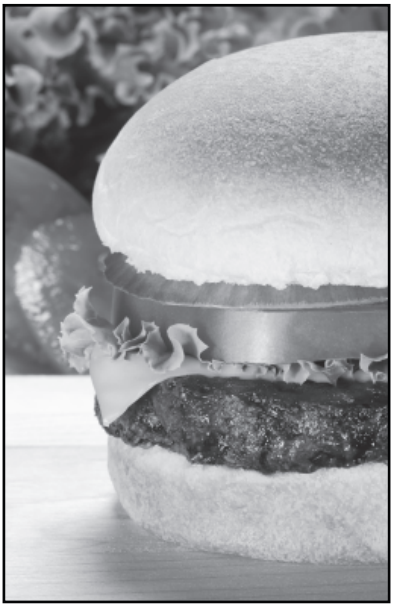
- Why wouldn't the organ thief just take all the organs and leave behind no witness? In any case, such stories always happen to a friend of a friend. When investigated, they never lead back to the original source but are often spread by reporters in newspapers or online articles.

Food Myths

- Have you heard that if you leave a fast-food hamburger out it will remain fresh for months? The implication is that the hamburger is so full of artificial ingredients and preservatives that it will not rot, as regular food should. The claim that the hamburger will not rot is sort of true, but the interpretation is suspicious.

- The obvious experiment is to buy 100 percent beef from the supermarket, cook it, leave it out, and see what happens. A good experiment would also compare this to the fast-food version and control for variables such as thickness, thoroughness of cooking, the presence of a bun, and whether it is kept in a sealed container.

When such comparisons are done, it turns out that any thoroughly cooked hamburger—especially if it is left uncovered—will not rot or mold. The reason is the lack of water; the dried-out meat will not decay. In humid conditions, or when sealed to trap in moisture and prevent drying, the expecting molding and rotting occurs.



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There's nothing artificial about fast-food hamburgers that make them not rot if left out for months; it is merely the moisture content.

- You may have also heard that the artificial sweetener aspartame is responsible for many diseases and symptoms. Since 1998, there has been a letter circulating claiming that aspartame is responsible for an epidemic of multiple sclerosis, lupus, Parkinson's disease, and other diseases.

- Some people further claim that at high temperatures, the wood alcohol in aspartame coverts to formaldehyde, ultimately resulting in methanol toxicity, which mimics multiple sclerosis and lupus.

- Aspartame has been approved for years by the FDA. Promoters of these aspartame fears also claim there is a conspiracy among manufacturers, the medical community, and the FDA to hide the truth. Apparently, the mainstream media is either in on the conspiracy or is simply incompetent. The websites also contain undocumented claims and anecdotal reports. There are many red flags for skepticism.

- There are numerous observational and experimental studies looking into aspartame toxicity. Epidemiological studies have found no association between aspartame use and any disease or symptom. Experimental studies have shown no toxicity even at doses 100 times the average daily consumption by users.

- The claim that aspartame is broken down into formaldehyde is true but misleading. The breakdown products of aspartame are mostly excreted from the body, but a small amount is converted ultimately to formaldehyde. However, formaldehyde is also produced by natural metabolic processes in the body. The small extra amount resulting from aspartame is negligible and has no measurable health effect.

- Claims like this are seemingly endless on the Internet and in popular culture. In order to assess such claims critically, consider the source and the plausibility of the claim, including all the implications. Then, try to find multiple reliable sources of information to see if there is a consensus of opinion.

Common Marketing Strategies

- Such phenomena as the psychology of belief, cognitive biases, and innumeracy can be exploited in order to manipulate you into buying something you otherwise would not buy. In fact, there are journals dedicated to marketing research—the science of psychological manipulation for making sales.

- Why are so many products priced at $19.95? Are people really fooled into thinking that $19.95 is significantly different from $20? The answer is yes: We have a **leftmost-digit bias**, in which the leftmost digit disproportionately affects our assessment of cost and value. We see this also with odometer reading and used cars; retail prices for used cars drop significantly at each 10,000-mile increment.

- Exploiting our need for self-esteem—specifically, our need to appear consistent to others—a salesperson may ask whether

you think a feature of a product is useful or if the product itself is handy after you have said no to buying it. Then, if you answer them in a positive way but still refuse to buy the product, you seem inconsistent.

- The ultimate manifestation of this involves getting down to the last objection. If the customer raises an objection, the salesperson can say, "So, if it were not for this one thing, you would buy the product?" Then, the salesperson will remove that final objection, and if you still don't buy the product, you essentially have to admit that you just lied.

- Many purchase decisions are made subconsciously. Eighty percent of luxury-item purchases are impulse buys. This allows for psychological factors to play a large role. For example, the anchoring heuristic can make a price seem low by anchoring to a higher base price.

- In addition to guarantees of satisfaction and making potential customers worry about nonexistent problems, guilt is another common form of psychological manipulation. Have you ever received a request for a donation with personalized address labels or a survey request with a small amount of money enclosed? The free gifts are meant to apply guilt to make you fill in the survey or send in a donation.

Psychological Manipulation

- Such sales schemes as multilevel marketing are unsustainable, and each new level needs geometrically greater sales people to sustain the pyramid. In addition, multilevel marketing schemes turn customers into a sales force. It is easier to convince someone of the value of a product if they in turn are trying to convince others of those virtues.

- Most multilevel marketing salespeople lose money. They are mostly just deluded customers, buying products for their own use or just to

make a quota—even though they have no chance of selling what they are forced to buy.

- Whether in a multilevel marketing model or a more traditional model, dubious health products are increasingly common. They often make claims that are too good to be true—that appeal to wishful thinking, such as losing weight without effort. At times, sellers of these products incorporate conspiracy claims to explain skepticism. They often rely on testimonials because storytelling can be very compelling. Additionally, they frequently misrepresent or misuse the scientific evidence.

- Cults are another phenomenon that uses psychological manipulation. Cults manipulate the environment to cause disorientation, sleep deprivation, and even nutritional deprivation.

- Members of cults inundate prospective members with love to make them feel unconditionally accepted. They then build a sense of in-group acceptance and out-group rejection. They isolate members from their family and friends, creating dependency on the group. Additionally, the cult leader is a charismatic individual, who encourages the surrendering of critical thinking.

Important Terms

leftmost-digit bias: The tendency of people to focus disproportionately on the leftmost digit of a number when assessing overall value or amount.

Nigerian scam: A type of scam in which the target is promised a large sum of money for helping a foreign national move money into the target's country, but only after money is paid for bribes, customs, and other needs.

spam: Unwanted e-mail messages usually used for advertising or to spread rumors or propaganda.

Suggested Reading

Brunvand, Fleming, and Boyd, *The Big Book of Urban Legends.*

Fitzpatrick and Reynolds, *False Profits.*

Novella, "Aspartame Safety and Internet Urban Legends."

———, "The Burger 'Experiments.'"

———, "The Internet and Skepticism."

Singer and Lalich, *Cults in Our Midst.*

Questions to Consider

1. How do marketers and salespersons exploit human psychology in order to manipulate their potential customers?

2. What methods can protect you from rumors and false information spread on the Internet and elsewhere?

Science, Media, and Democracy

Lecture 22

We live in a world increasingly dominated by science; however, most people don't have the basic critical thinking skills and scientific knowledge required to deal with the relevant science. In a free society, citizens have both a responsibility and a burden to not only stay well informed, but also to have the knowledge and skills to assess important issues of the day. This lecture covers the strengths and weaknesses of media reporting—especially of scientific and controversial topics—and the intersection of science with politics and social issues.

Finding Reliable Information

- Before accepting any piece of information as probably true, make some attempt to verify it. Do not trust any one source as definitive. If possible, see what multiple, independent sources have to say. This is becoming more challenging on the Internet because, often, a single source is repeated endlessly on many websites.

- A very useful strategy is to specifically look for disconfirming information, or a contrary opinion. Searching for the topic of interest with key words such as scam, skeptics, skeptical, or fraud can help. See what all sides are saying about an issue before deciding who has the strongest case. It's easy to make what seems like a convincing case if you are only presenting one side.

- There have been many reviews of online information quality that have found that even the best sites have problems. In general, don't trust sites that are trying to sell you something or have an apparent political or ideological agenda.

- The more controversial a topic is, the greater the chance that information will be skewed or biased. In such cases, it is especially important to survey a number of sources to get the broadest

perspective possible. Some topics are genuinely controversial—even among experts.

- For example, are biofuels a useful strategy for achieving energy independence and limiting greenhouse gases? At present, for ethanol specifically, whether more energy comes out of the process than is put in depends on how the calculations are made, so experts disagree.

- In addition, there are many so-called **manufactroversies**, or questions that are not controversial among scientists or experts but are made controversial by ideological groups.

- For example, experts largely agree that vaccines are both safe and effective, but there is a vocal group of antivaccine activists that create a tremendous amount of information online that argues the opposite.

Pitfalls of Science Journalism

- Many people get the majority of their science news from the mainstream media—whether online or from more traditional venues like television and newspapers. Therefore, it is critical to have a working understanding of the strengths and weaknesses of how the media presents science. The quality of information is highly variable, as is the background knowledge and skills of journalists and editors. In addition, not all scientists know how to interface with the media, and they may unwittingly contribute to misinformation.

- An example of bad science news reporting involves the story of Lee Spievack, who reportedly cut the end of his finger off. However, his brother owned a company that was researching a tissue regeneration powder made from pig bladders, whimsically called pixie dust, which allegedly helped Spievack regrow his lost finger.

- This is what we call science by press release. With decreasing revenue going to traditional journalism, news sites have had to

cut back. Many have reduced or eliminated their science reporting divisions, and now generalist journalists and editors are covering the science beat. Distressingly, many outlets reprint, sometimes with little or no alteration or fact-checking, science press releases.

- There are many problems with this. Even respectable universities have a press office that may try to sensationalize a news story to get their institution in the news. Often, the researchers have little or no input into the copy of the press release. Furthermore, private companies can use the science press release essentially to advertise their products or drum up interest in their company, perhaps to attract investors.

- In this case, the story was generated by Spievak's brother, who was apparently trying to increase interest in his company and its new product. The story is almost entirely bogus: Spievek did indeed injure his finger, but not a single joint was missing; all that happened was typical wound healing. Sometimes the very ends of fingers can regrow with such healing, but this is very different than the impression given in the press. Essentially, the press was duped by a self-serving marketing campaign—or perhaps many didn't care, as long as they got their sensational headlines.

- Another story involves Dr. Paolo Zamboni, an Italian vascular surgeon who claims he has found the cause, and cure, for multiple sclerosis. He claims that multiple sclerosis is due to a condition known as chronic cerebrospinal venous insufficiency (CCSVI), which is a partial blockage in the veins that drain blood from the brain.

- Furthermore, Zamboni claims that he can cure multiple sclerosis by opening up this blockage with venous angioplasty and stenting. This has excited the multiple sclerosis community, and the media around the world breathlessly reported how this lone maverick has challenged decades of multiple sclerosis dogma.

- There are multiple problems with how this story has often been reported. Many reporters make the mistake of confusing the authority of an individual with the authority of the scientific community. No matter how many letters someone has after his or her name, the opinions of that person are still the quirky opinions of one individual, but reporters often defer to such authority.

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It's important to raise the overall quality of science news reporting because it's where most people get most of their information.

- Good journalism, however, should put the opinions of one expert into the proper context. Furthermore, the press loves stories about a so-called lone maverick taking on traditional beliefs; it's a narrative that resonates within our culture. Sometimes, those mavericks turn out to be correct, but far more often, their speculations do not hold up under further research.

- This represents another common error: confusing speculative research with confirmatory research. Most speculative research turns out to be wrong in the long run, but the public is often treated to an endless sequence of scientific research and then never hears that the preliminary findings turned out to be wrong. Much of science news reporting is simply premature.

- In this case, Zamboni's claims have now been replicated many times, and most of the follow-up studies have not found what he found. Many patients with multiple sclerosis do not have venous blockage, and many patients without multiple sclerosis do. Furthermore, the evidence continues to pile up that multiple sclerosis is an inflammatory disease with genetic predisposition.

- Unfortunately, the promise of a potential cure for multiple sclerosis has caused some in the multiple sclerosis community to rally behind Zomboni, despite the negative evidence that comes in. Some are calling for clinical trials, which seem premature given the negative evidence. Some even claim that there is now a conspiracy against Zamboni—perhaps just to explain the evidence.

- This situation was greatly exacerbated by the premature press reporting. This is part of the double-edged sword of free access to information. Traditionally, these scientific controversies would be worked out in the scientific literature and at professional meetings—long before the public was made aware of them. However, the Internet changes that.

- Public accessibility to such controversies is good in the long run, but the public now has to be educated more about the messy process of science—and specifically about the nature of speculative research. In other words, it is essential to remain skeptical of new ideas until they have had time to go through the process of scientific research, peer review, and replication.

- Most new ideas in science fail, but if an idea turns out to be correct, it will stand the test of time. Therefore, the public needs to learn patience and healthy skepticism when it comes to new ideas in science, despite the frenetic pace and short attention span of the news cycle.

False Balance

- Another chronic problem with many science news stories, especially those about controversial topics, is what we call **false balance**. Standard journalistic practice is to cover both—or all—sides of an issue equally. This makes sense when it comes to politics, or areas where opinion is dominant, but this approach does not work well with science news.

- Science is about verifiable and testable factual claims. There is often a huge asymmetry in a science controversy or topic. For example,

there is a small minority of people who believe that Earth is gaining matter and growing significantly. Furthermore, they believe that the reason the continents seem to fit together like a puzzle is not because of plate tectonics but because at one time, Earth was only as big as the continents, and they broke up when Earth grew.

- When subjects like this get covered, however, reporters will feel obliged to give the issue balance, so they have one supposed expert present the growing Earth theory, and then a regular scientist explains what the other 99.9 percent of the scientific community think. Simply presenting the two views as equivalent gives a very false impression to the public, elevating the fringe idea to equal status.

- In recent science news, it was reported that researchers from the OPERA experiment (Oscillation Project with Emulsion-tRacking Apparatus) measured the speed of neutrinos, a type of primary particle, as faster than the speed of light. This violates Einstein's theory of special relativity and is sensational science news—if true.

- However, the results are almost certainly in error; even the researchers acknowledge this. The neutrinos were faster than the speed of light by only 60 nanoseconds, and there are several proposed causes for the error.

- At this time, there is no definitive answer; it is a genuine scientific puzzle. However, it is likely that the media will not present the prosaic answer with as much enthusiasm or as high of a profile as the initial—and almost certainly incorrect—findings.

- Critical thinking is not just about science. In fact, the more political and emotional an issue is, the more critical thinking is necessary. This raises an important question: What is the relationship between science and politics, ethics, and values?

- There is a range of opinions on this question, which is ultimately philosophical. The position that has the most merit is that science

can inform ethical thinking, but there will always be some subjective value judgments in the mix.

Science Education and Democracy

- In democratic, industrialized nations, it is important for citizens to have a working knowledge of science, which involves the ability to have a basic understanding of important science-related issues of the day.

- Research has shown that the vast majority of people living in industrialized nations do not have the minimal scientific knowledge to participate in important scientific issues of the day. Experts propose a number of possible causes, and fixes, for this problem.

- Obviously, the quality of science education needs to improve at all levels. Science textbooks also are frequently criticized for poor quality. One study shows that requiring science classes for nonscience majors at the college level has a significant impact on scientific literacy. Improving the overall quality of science reporting, and science in mainstream media, is also important.

Important Terms

false balance: The treatment of a topic in journalism as if it is controversial when it isn't, or treating two sides of an issue as if they are scientifically equal when they are not.

manufactroversies: A false controversy created in order to make a scientifically accepted idea seem uncertain or controversial.

Suggested Reading

Goldacre, *Bad Science.*

———, "Why Don't Journalists Link to Primary Sources?"

Hazen and Trefil, *Science Matters.*

Novella, “CCSVI—The Importance of Replication.”

———, “Science Education and Literacy in the U.S.”

Spellman and Price-Bayer, *In Defense of Science.*

Questions to Consider

1. What common traps do journalists fall into when reporting science news stories?

2. What are the risks to a modern democracy if the population is largely scientifically illiterate?

Experts and Scientific Consensus

Lecture 23

The goal of this course is to make you think about thinking itself, but no one person can be the definitive authority on a complex topic. Some individuals do possess genuine expertise, and their opinions should at least be taken more seriously than the average person. Expertise, however, is a complex topic because there are many levels of expertise. True authority, if such exists, rests with the consensus of opinion among relevant experts—not with any single individual.

The Nature of Scientific Consensus

- We rely on experts all the time. Every time you visit a professional—a doctor, lawyer, accountant, or hairdresser—to some extent, you are deferring to the perceived expertise of that professional. Otherwise, we could not function in our complex civilization.

- Nobody can be an expert in everything, so it's reasonable to defer to expertise—to people who spend their lives mastering one small craft or area of knowledge—although it's also a good idea to have enough of a basic understanding of important areas of life that you can judge if someone is a true expert or, perhaps, just faking it.

- From one perspective, it takes an expert to truly know an expert. However, there are some things you can do to judge genuine expertise. Is the individual licensed in his or her trade or profession? Can the supposed expert document that he or she has had adequate training and has maintained a level of expertise? Are the individual's views representative of the profession, or are they on the fringe? Finally, do the views of this person make sense? If not, get a second opinion.

- It is more difficult to judge an entire profession than an individual. Many professions become established, create the trappings of

legitimacy, and even gain licensure without ever developing true scientific legitimacy. Psychics and astrologers, for example, often have their own organizations and institutions. In some states, they are even licensed.

- Licensure is often granted as a means of controlling an industry, establishing professional standards, and collecting licensure fees. However, licensure is too often interpreted by the public as indicating that the body of knowledge on which the profession is based is scientifically legitimate.

- Licensure is all about internal legitimacy—following the rules of the profession and filling out the paperwork, for example. External validity, however, means that the body of knowledge has been tested against reality and that there are mechanisms of self-correction and transparency. Without the methods of science to truly evaluate a system of knowledge, there is no way to establish external validity.

- Some professions, such as the chiropractic profession, exist in the gray zone between internal legitimacy and external validity. Some of their practices are supported by evidence—such as lower back manipulation for uncomplicated acute back strain—but much of what they do is not validated by science and is, in fact, at odds with modern medical science. There is no system of external validity within the chiropractic community, however. There is no universal science-based standard, so dubious practices proliferate and continue.

- There is no guarantee of legitimacy. There are indicators, but nothing is definitive. Furthermore, there is no substitute for a critical analysis.

The Nature of Expertise

- A common mistake that many people make is to consider someone who is an expert in one thing to be an expert in all things—as if they can have general expertise. Sometimes experts make this mistake themselves and stray from their true area of knowledge.

- Lord Kelvin was a legitimate expert in physics—specifically in thermodynamics—but that did not give him the expertise to make pronouncements about other areas of science, such as geology, nor to declare that attempts at an airplane would never be successful. Late in his career, Lord Kelvin was mistaken again when he declared the initial discovery of X-rays to be a hoax, but he soon changed his mind when he saw the evidence and even experienced an X-ray of his own hand.

- Sir Isaac Newton, the 17th-century mathematician and scientist, is another example of a famous scientist from history who maintained ideas that are now considered pseudoscience. While there is no question that Newton was a genius and that his advances in physics, specifically mechanics, transformed our understanding of science at the time, he was also very interested in alchemy. He spent much of his time engaged in alchemical research without any tangible results. To Newton, alchemy was central to his beliefs about how the world works—as much as mathematics and physics.

Mathematician and scientist Sir Isaac Newton (1642–1727), a genius in physics, was also very interested in alchemy, a pseudoscience.

- Linus Pauling is the only scientist to win the solo Nobel Prize twice. In addition to being an iconic science award, the Nobel Prize carries with it the ultimate imprimatur of expertise. However, that did not stop Linus Pauling from adopting fringe ideas toward the end of his career.

- Linus Pauling promoted the idea that megadoses of vitamin C could treat or prevent the common cold. He later expanded this claim to include the flu, a more serious illness. Furthermore, he claimed that

megadoses of vitamin C could help cancer and that high doses of vitamins in general could promote health. His claims were never based on adequate scientific research, and subsequent research has shown his claims to be essentially false. However, because of his prestige, he had a tremendous influence on the public.

Experts and Overconfidence

- Experts are also notoriously fallible, especially when asked to make predictions. There tends to be an inverse relationship between individual confidence and accuracy. When it comes to predicting the future behavior of complex systems, even experts are all but useless—but that does not prevent the popularity of asking experts to make such predictions.

- Predicting the future in general is highly problematic. So-called futurism is very popular and may serve a purpose in terms of preparing for possible future technologies. However, the track record of futurists is appallingly bad.

- The overconfidence of experts relates partly to the **Dunning-Kruger effect**. In 1999, psychologists David Dunning and Justin Kruger described how those who are incompetent are generally unaware of their own incompetence; the same failings that make them incompetent also make them unable to see it. This leads to what is more casually referred to as the arrogance of ignorance. True expertise is comprised of an appreciation for the limits of knowledge—both individual and systemic.

- When it comes to scientific questions, there are two related but distinct types of expertise: the relevant science and critical thinking. Those with critical thinking skills but who lack specific scientific knowledge will still have difficulty thinking about scientific questions. Specific in-depth knowledge is still important to developing opinions about scientific questions.

- In addition, scientific knowledge itself may not be enough without critical thinking skills. Scientists who are insufficiently skeptical of

their own claims tend to make critical thinking errors that result in serious errors. In order to avoid these kinds of errors, both science and critical thinking are needed.

- Sometimes scientists believe that their scientific knowledge is enough, but this can make them easier to fool because they will be overconfident in their own ability not to be fooled. A famous example of this, called Project Alpha, involved researchers at Washington University who were given a grant to test alleged psychic abilities. Magician James Randi offered his consultation as an expert in deception to show the researchers how to avoid being tricked, but his help was refused.

- To demonstrate the need for the specific expertise of deception in ESP research, Randi sent in two teenagers who were able to completely fool the researchers with simple sleight-of-hand tricks. The researchers were overconfident in their research skills but were not prepared for deliberate deception; they were not experienced skeptics.

- Individuals are biased, quirky, flawed, have incomplete knowledge, and have a tendency to overestimate their own knowledge and expertise. However, some people have spent years mastering arcane knowledge. It's no guarantee of legitimacy or correctness, but it's at least worthy of being taken seriously.

- The quirkiness of the individual is why a consensus of opinion is much more reliable. Individual biases will tend to average out. Gaps in knowledge and perspective will also tend to compensate for each other. Within science, differences of interpretation will tend, over time, to get resolved by seeking better evidence. Eventually, consensus is built upon solid ground.

- This does not mean that the consensus of scientific opinion is always correct, but the probability of being correct is higher than the opinion of an individual. If you are going to disagree with the consensus of opinion, there should be a good reason.

Determining Consensus of Scientific Opinion

- Sometimes it may be difficult to determine what the consensus of scientific opinion is on a topic. Different specialties may have a different opinion. For example, geologists are fairly convinced that a single asteroid wiped out the dinosaurs about 65.5 millions years ago. However, many paleontologists are not convinced. There was certainly an asteroid impact at that time, but some believe that the fossil evidence suggests a longer extinction of the dinosaurs.

- The nature of consensus about global warming has been intensely debated. The International Panel on Climate Change (IPCC) represents a consensus of opinion among climate scientists, but some have criticized the process as political.

- It seems that there is a robust consensus that Earth is warming, and anthropogenic causes are important, but there remains minority dissent. Political entities with strong opinions on this issue have challenged the notion that there is a consensus and have promoted the views of dissenters.

- A 2011 study by Richard Muller—a physicist at the University of California, Berkeley—sought to replicate prior analysis by NASA and other temperature data about Earth. Muller was skeptical of prior analyses and the conclusion of warming, so he set out to disprove it. He and his team conducted their own analysis of all available data and concluded that Earth is warming by 0.9 degrees Celsius over the last 50 years. Furthermore, their temperature map closely matches that of NASA and others, confirming the prior analyses of which they were doubtful.

- In the end, Muller changed his mind and accepted the fact that the planet is warming. This is an excellent example of how science should work. Disagreement was resolved by further analysis, and the data held sway. As a result, the consensus on global warming was strengthened. However, it does not seem that this will end the political controversy over global warming.

- The consensus of scientific opinion is an important factor to consider when evaluating any claim. A robust consensus should be built on evidence and hammered out in the research and at meetings. Consensus is more reliable than the opinions of any one scientist, but it is no guarantee.

- While it is reasonable to respect a hard-won consensus, there is also a role for dissenting opinions. As with science in general, there is never any guarantee of being correct. The goal is simply to maximize the probability of being correct while remaining open to new evidence and analyses.

Important Term

Dunning-Kruger effect: The phenomenon that one's incompetence in a particular area also renders the individual incapable of detecting his or her own incompetence, resulting in a false sense of confidence.

Suggested Reading

Burton, *On Being Certain*.

Freedman, *Wrong.*

Gardner, *Future Babble.*

Hallinan, *Why We Make Mistakes.*

Novella, "Beware the Nobel Laureate Argument from Authority."

———, "The Nature of Consensus."

Wilson, *Consilience.*

Questions to Consider

1. Why do experts frequently make serious mistakes?

2. What does it mean that there is a scientific consensus on any particular question?

Critical Thinking and Science in Your Life

Lecture 24

This lecture will review the critical thinking skills outlined in this course. Taken together, they represent an outlook on science, claims, and belief that is referred to as scientific skepticism. Skepticism refers to an appreciation for the limits and foibles of the human brain combined with the power of the self-corrective approach of science; it puts in place a rational filter through which all claims to truth must pass. This lecture describes the skeptical approach, including how to deal with friends, family, and coworkers. It also covers scientific education and scientific literacy.

Investing in Critical Thinking

- The human brain, although powerful, has many flaws and weaknesses. We only perceive and attend to a small amount of the world around us, and that sensory information is highly filtered, processed, and ultimately constructed. Immediately after we experience that highly altered sensory information, our memories start to further alter it. Every time we remember something, we add, change, and fuse details; we update the memory.

- Humans are both rational and emotional creatures. We come with a suite of emotional needs and biases. Our default mode of operation is to make decisions for unconscious or only dimly seen reasons and then rationalize them with motivated reasoning. We then succumb to errors and biases in thinking, logical fallacies, insufficient information, and a poor grasp of math and statistics.

- There are many cognitive biases that conspire together to lead us to take and firmly hold beliefs that potentially have little or no relationship to reality. What we believe is a narrative that is stitched together from flawed information and modified by our cognitive biases and emotional needs and desires. This is an essential realization—one that separates critical thinkers from those who think less critically.

- Once we accept that we cannot trust what we think we remember, we become humble in the face of our experiences and knowledge. Then, we are open to the dire need for a systematic approach to knowledge—methods to compensate for all the many flaws of our brains' function.

- In a way, science and critical thinking are our fix for all the flaws in human reasoning. That is why it has transformed our understanding of ourselves and of the universe in which we live. However, even for those who have a working knowledge of critical thinking, it's difficult to fully appreciate the potential for self-deception.

- There is a tendency to grossly underestimate the human potential for self-deception, even among skeptics. We all want to view ourselves as rational beings, but that is the greatest self-deception of all. If you think you are not biased and cannot rationalize a completely erroneous belief, then that bias can undo all of your critical thinking skills.

- Often, scientists and great intellectuals may become more susceptible to self-deception because they lose their intellectual humility. The ultimate lesson of our understanding of neuroscience and psychology is humility in the face of our own knowledge.

- Millions, or perhaps even billions, of people can be profoundly wrong about a belief for hundreds or even thousands of years. Entire cultures may endorse a belief system that is strongly reinforced by confirmation bias. Eventually, the apparent examples of support seem overwhelming. There is also extreme social pressure to conform because our in-group identity is tied to the belief system.

- Most of all, it is important to apply the rules of critical thinking to yourself—but there are barriers to this. Once you invest your ego in a conclusion, motivated reasoning will distort and bias your critical thinking into that direction. In the end, you will still be wrong; you will just be more confident in your error.

- If, on the other hand, you invest your ego in the process of critical thinking, and not in any particular conclusion, then you will be freer to follow the logic and evidence wherever it leads. You will, in fact, take pride in the ability to change your opinion as new information becomes available.

Critical Thinking and Scientific Knowledge

- We cannot change human nature. However, recent neuroscience is finding that the brain can actually change its wiring in response to use. This is called brain plasticity. Sometimes, this is simple learning; the brain can learn and remember. Habits of thought can also become ingrained.

- However, you cannot change your basic personality profile. Personality has proven to be a remarkable resistant to change. What you can change is how you deal with your basic emotional makeup. This begins with what some psychologists call emotional intelligence, which is an insight into your emotional makeup. This is why knowledge of psychological needs and cognitive biases is so important.

Recent neuroscience has found that the brain is plastic; in other words, it can change its wiring in response to use.

- We cannot change our basic evolved emotional needs and reactions, but we can change how we respond to those emotions. We can engage our frontal lobes, our executive function, and develop adaptive responses. These responses can be learned and ingrained through habit and effort.

- The application of rational thought, scientific methods, and skeptical thinking frequently prompts some to ask whether this approach to life denies human emotions. However, the full emotional palette is part of the human condition, and it is healthy—even rational—to embrace it.

- We live in a beautiful, subtle, elegant, and complex universe. Understanding something about how it works has a profound beauty of its own.

- In terms of theories and facts, there is no absolute right and wrong; there are only degrees of confidence. Furthermore, all conclusions are tentative because our information is always incomplete. Empirical knowledge is a journey—not a destination. If, however, you think you have arrived at absolute truth, then your journey of science and critical thinking is over.

- To be a critical thinker is to be comfortable with uncertainty and with the limits of human knowledge and to be aware of all the many flaws and limitations of human intelligence—and, therefore, to be flexible in the face of new ideas or information but to not be afraid to acknowledge that some ideas are objectively better than others.

- Reliable scientific knowledge is possible. Logic can be valid or not valid. Some data is more reliable than others. Being flexible does not mean being gullible in the face of any claim; it means critically analyzing all claims and judging them on their merits.

Applying Critical Thinking Skills

- When someone states a belief or claim that you believe to be wrong or invalid, you first have to recognize that nobody likes being told

that he or she is wrong or having a valued belief taken from him or her. At the same time, you don't want to appear to be accepting an illogical or false belief.

- There may be important decisions at stake, such as whether to seek an unconventional treatment for a serious illness. One approach that is helpful is to simply ask questions; engage the other person's natural tendency to be curious and ask questions.

- In addition, recognize that it is extremely rare for someone to simply abandon a valued belief when confronted with disconfirming information. In fact, recent psychological research shows that when this happens, people tend to hold the erroneous belief even more strongly.

- Instead of challenging their belief, give analogies or examples that would encourage them to question aspects of their belief. Plant a seed of critical thinking, and then encourage it over time.

- Critical thinking is the process of engaging your higher cortical function as a filter and control on the more primitive parts of the brain. Not only can we all strive to engage in more critical thinking ourselves, but we can also strive to make those around us more critical.

- Furthermore, if our goal is to engage society overall in more critical thinking, then we can also change our educational system. Additionally, our culture can change, especially the way in which science and information is presented in the media.

- Our society does a generally poor job of teaching critical thinking and scientific literacy. As a society, we can learn to approach science and education as a process rather than as a set of answers that never change. Science news items should be framed as part of an ongoing process of scientific discovery—not always as a definitive breakthrough that finally gives us the answer to a scientific mystery.

Education should focus on teaching children the process of science—not giving them authoritative answers to memorize.

- Additionally, we need to think of education as more than what happens in the classroom. The evidence shows, in fact, that most learning takes place outside the classroom.

- More scientists are engaging in blogs, podcasts, and other new media to make their scientific discipline accessible to the public.

- In statistical analysis, the method of constantly updating our knowledge as new information comes in is called a **Bayesian analysis**. We look at all the knowledge that currently exists to arrive at the best current answer to any question, and we acknowledge all the limitations and uncertainties in the data and in our conclusions. Then, we constantly update our tentative conclusions as new data comes in.

- Science, skepticism, and critical thinking—including formal logic—are rigorous processes that we use to handle the complexity of the world because our flawed brains are not up to the task by themselves.

- It is this process of updating that should be reflected more in the classroom and in the media—not approaching science as an arcane ritual that is understood only by scientists within a given field and that spits out authoritative answers.

Critical Thinking and Metacognition

- The critical thinking approach to knowledge and life is very empowering, and its power comes from its acceptance of reality.

- Scientific skepticism is a mature view of the human condition and knowledge. It is not scandalized by the flaws in the human efforts of science—nor is it naive about the existence of those flaws and the limitations of the human brain. The critical thinking approach

involves doing the best that we can with full knowledge and appreciation for those weaknesses and limitations.

- The goal of this course is to understand all of the cognitive and other biases that rule our thinking. Without understanding of these biases, we are destined to simply be carried along by our flawed inclinations.

- With a thorough understanding of logic and cognitive biases, however, we have the opportunity to engage in metacognitive reasoning. We can consciously put into place a metacognitive self-check on our own reasoning. We engage our frontal lobe executive function to filter and inhibit our more primitive cognitive impulses. We can try to transcend our biases by being truly aware of them.

- Even with the understanding of metacognition, when logic and evidence leads us to uncomfortable conclusions, this will create cognitive dissonance. Recognizing that dissonance and how it will motivate you empowers you to engage in metacognition—to choose an adaptive, rational resolution rather than rationalizing a convenient answer.

- Metacognition is not easy, and it takes practice, knowledge, and dedication to stay in the metacognitive realm—to allow the facts and logic, rather than our biases and emotions, rule our thinking.

Important Term

Bayesian analysis: A method for calculating the odds of a theory or phenomenon being true by updating the prior probability as new facts and information become available.

Suggested Reading

Ariely, *Predictably Irrational, Revised and Expanded Edition.*

Chabris and Simons, *The Invisible Gorilla.*

McRaney, *You Are Not So Smart.*

Novella, "How Gullible Are You?"

Tavris and Aronson, *Mistakes Were Made (But Not by Me).*

Questions to Consider

1. How can we apply critical thinking skills in our everyday lives?

2. How does an understanding of the details of our cognitive frailties empower us to transcend them?

Glossary

ad hominem: A logical fallacy in which an assertion is said to be false or unreliable because of an alleged negative attribute of the person making the assertion; arguing against the person rather than the claim itself.

agnostic: The notion that unfalsifiable hypotheses, such as the existence of God, are not only unknown—but are also unknowable.

alien hand syndrome: A neurological syndrome in which a person's limb, such as a hand, feels as if it is acting on its own—without conscious control. This results from damage to the brain pathways that compare the intention to move with actual movements.

anchoring: The tendency to focus disproportionately on one feature or aspect of an item or phenomenon and base judgments on that one feature.

anecdote: An uncontrolled or poorly documented observation or experience.

anomaly: A phenomenon that is incompatible with or cannot be explained by current scientific theories.

argument: A statement that is used to support a conclusion or belief, often following deductive reasoning.

availability heuristic: The tendency to believe that a phenomenon is more likely or more important if we can readily think of examples of the phenomenon.

base-rate fallacy: Failure to consider how common a phenomenon is (the base rate) when estimating how likely it is, preferring other factors such as representativeness.

Bayesian analysis: A method for calculating the odds of a theory or phenomenon being true by updating the prior probability as new facts and information become available.

blinding: In scientific studies, this refers to the process of hiding the status of a subject (whether they are in the intervention or the control group) from the subject (single blind) or also from the experimenter (double blind).

change blindness: The experimentally verified tendency of humans not to notice changes in their environment.

clustering illusion: The tendency of people to underestimate the clumping of statistically random distributions, which gives the illusion of clustering.

cognitive bias: A subconscious tendency to think in a certain way, or a bias toward certain decision-making pathways.

cognitive dissonance: An unpleasant emotion generated by the simultaneous existence of mutually exclusive beliefs.

cold fusion: A hypothetical technique that causes nuclear fusion to occur at relatively low temperatures, especially in a way that would be practical for energy production.

cold reading: A mentalist technique by which the reader can seem to have specific knowledge of the target (the subject of the reading) using vague or high-probability guesses and feedback.

collective wish fulfillment: A form of mass delusion characterized by the fulfillment of a common desire or wish, such as making a fantastic discovery.

community flight panic: A form of mass delusion in which fear or an immediate threat spreads through a town or community, causing many to flee from the alleged threat.

confabulation: The filling in of details missing from either perception or memory. The brain invents the missing details to construct a consistent narrative.

confirmation bias: A cognitive bias to support beliefs we already hold, including the tendency to notice and accept confirming information while ignoring or rationalizing disconfirming information.

congruence bias: The tendency to test our own theories but not alternative theories, which can lead to a false sense of confirmation of our own beliefs.

constancy: The fact that our brains construct a constant and consistent model of what we perceive that generally matches reality.

control group: In an experimental study, the control group receives a sham or placebo intervention that is physiologically inert so that it can be compared to the treatment group.

critical thinking: Applying systematic logic and doubt to any claim or belief; thinking carefully and rigorously.

data mining: The process of sifting through large sets of data and looking for apparent patterns. This is a legitimate way to generate hypotheses—but not of confirming them—because this process lends itself to finding illusory patterns.

deductive reasoning: Reasoning that begins with one or more general statements that are taken as premises and then concludes what must be true if the premises are true.

default mode: A common behavior that results from evolved emotions and subconscious processes without metacognitive insight.

delusion: A fixed, false belief that is vigorously held even in the face of overwhelming contradictory evidence.

demarcation problem: A philosophical term that refers to the difficulty in clearly defining a separation between two ends of a continuum, such as the difference between science and pseudoscience.

denialism: A form of pseudoscience that uses poor logic and distortion of science in order to deny the conclusions or legitimacy of an accepted scientific theory or fact.

Dunning-Kruger effect: The phenomenon that one's incompetence in a particular area also renders the individual incapable of detecting his or her own incompetence, resulting in a false sense of confidence.

electronic voice phenomenon (EVP): The phenomenon of apparent words or phrases being found in audio recordings of allegedly haunted locations. Believers ascribe EVP to ghost phenomena, but they are more easily explained as audio pareidolia.

epidemiology: The study of the incidence, spread, and associated factors of disease.

epistemology: The branch of philosophy that deals with knowledge and the methods of science.

executive function: A function of the frontal lobes of the brain, specifically the ability to control and plan one's behavior to meet long-term self-interest and social integration.

exemplar: A case that vividly represents a phenomenon, making it seem more likely, common, or significant.

experimental study: Scientific studies that involve a specific intervention performed by the experimenters.

exposure effect: The tendency to more favorably rate things or beliefs with which we are more familiar.

false balance: The treatment of a topic in journalism as if it is controversial when it isn't, or treating two sides of an issue as if they are scientifically equal when they are not.

false continuum: A logical fallacy in which the fact that a characteristic varies along a continuum is used to argue that the extreme ends of the continuum do not exist or cannot be meaningfully identified.

false dichotomy: A logical fallacy in which multiple choices are reduced artificially to only a binary choice, or where a continuum is reduced to its two extremes.

false memory syndrome: The implantation of false memories that are thought to be real by the possessor of the memory, often resulting from strong suggestion, imagining, or hypnosis.

falsifiability: The key feature of any scientific hypothesis—that, at least theoretically, there must be some evidence to prove or imply that the hypothesis is not true.

flashbulb memory: A detailed memory or snapshot of a sudden, unexpected, and emotionally significant event.

folie à deux: A shared delusion between two individuals, in which one person tends to be dominant and the source of the delusion.

Forer effect: The tendency to take vague or general statements and apply them specifically to ourselves, or to find specific examples, making the statements seem more accurate and specific than they are.

free energy: The general term for any alleged process that produces energy without burning fuel or other limited resource.

free will: The ability of a sentient being to make voluntary choices and decisions. Philosophers argue about whether humans have true free will or just the illusion of free will.

functional magnetic resonance imaging (fMRI): Application of magnetic resonance imaging, a type of medical scanner, that can be used to image the degree to which different parts of the brain are active.

fundamental attribution error: A psychological term that refers to the tendency to ascribe the actions of others to internal motives and attributes rather than external situational factors.

gambler's fallacy: The false belief that prior events dictate the probability of future events, even when they are random and independent, such as the results of random coin flipping.

global workspace: A controversial theory (disputed by recent research) that posits that a distributed network in the brain is the common pathway for all conscious experience.

grand conspiracy: A large, far-reaching conspiracy often alleged to span multiple organizations, people, and even generations.

group delusion: A delusion shared among a small group, such as a cult, typically led by one charismatic leader.

heuristic: A cognitive rule of thumb or mental shortcut that we subconsciously make that may be true much of the time but is not logically valid.

hierarchy of needs: The term coined by Abraham Maslow that describes the relationship among the basic and higher human needs—from physiological needs like food to emotional needs like self-actualization.

hyperactive agency detection: The human tendency to detect a conscious agent behind natural or random behavior or events—for example, believing that random events are a conspiracy to punish us.

hypnosis: Although not a trance, hypnosis is a state of mind characterized by alertness but also by high suggestibility.

ideomotor effect: Subconscious muscle movements that conform to expectations.

inattentional blindness: This phenomenon refers to the lack of attention to sensory information, especially while attending to other sensory input. Significant information right before our eyes can be completely missed and is simply not processed.

inductive reasoning: Inductive reasoning begins with observations of the world and then derives general statements about what is probably true from those observations.

innumeracy: A lack of working knowledge of mathematics, probability, and statistics.

intelligent design: The term used to self-describe a new school of creationism that holds that life is too complex to have arisen from natural processes alone.

intuition: Decision making or feelings, such as responses to social cues, that derive from subconscious brain processes.

leftmost-digit bias: The tendency of people to focus disproportionately on the leftmost digit of a number when assessing overall value or amount.

logic: A formal process or principle of reasoning.

logical fallacy: A logical operation that is not valid.

long-term memory: Memories that have been consolidated into long-term storage.

lottery fallacy: The fallacy of using a specific post-event outcome to calculate the pre-event odds of any outcome. For example, the odds of a specific person winning the lottery may be very low, but that does not mean that the event is too unlikely to have occurred by chance alone because the probability of anyone winning was high.

manufactroversies: A false controversy created in order to make a scientifically accepted idea seem uncertain or controversial.

mass delusion: A delusion or false belief shared among a large group of people—even an entire community or culture.

mass hysteria: Similar to a mass delusion but specifically involving physical symptoms.

McGurk effect: The phenomenon that the consonant sounds we hear are affected by the lip movements we see.

meta-analysis: A mathematical process of combining the results of many studies into a single study for statistical analysis.

metacognition: Thinking about thinking; examining the processes by which we think about and arrive at our own beliefs.

methodological naturalism: The philosophical assumptions that underlie scientific methodology; specifically, the assumption that all effects have natural causes.

multilevel marketing: A corporate structure in which salespeople must pay a percentage of their profit to sponsors above them and, in turn, can sponsor salespeople below them who have to pay them a percentage.

multitasking: Dividing attention between two or more tasks or sensory inputs.

N-rays: A hypothetical type of radiation that was allegedly discovered by René Blondlot but that was eventually exposed as illusory.

neocortex: The neocortex is the most recently evolved portion of the human brain—specifically, the frontal lobes, which provide executive function, among other things.

Nigerian scam: A type of scam in which the target is promised a large sum of money for helping a foreign national move money into the target's country, but only after money is paid for bribes, customs, and other needs.

nonoverlapping magisteria (NOMA): The term coined by Stephen Jay Gould to describe his philosophy that science and faith are separate and nonoverlapping schools of thought.

non sequitur: A Latin term referring to an invalid argument in which the conclusion does not logically follow from the premises.

observational study: Scientific studies in which the behavior of groups are observed in the real world—without experimenter intervention.

Occam's razor: A rule of thumb, also known as the law of parsimony, that states that when two or more hypotheses are compatible with the available evidence, the one that introduces the fewest new assumptions is to be preferred.

optical illusion: The common term for the failure of constancy, or a breakdown in the process of creating a constant and consistent view of reality. Illusions occur when what our brain constructs does not match reality or when there is an inherent contradiction or ambiguity in the way perceptual information is constructed.

orb: The name given by ghost researchers to a sphere of light that is seen on film and believed to be evidence of ghosts but is more easily explained as a photographic artifact.

overprecision: A psychological term that refers to the tendency for people to overestimate the accuracy of their own knowledge.

overunity: A process that generates more energy than it consumes, in violation of the laws of thermodynamics.

ownership module: The part of the brain that creates the sensation that we own the various parts of our body.

paradigm: A term developed by Thomas Kuhn to refer to a set of scientific beliefs and assumptions that prevail at any particular time in history.

paranormal: Any belief or phenomenon that allegedly is outside the naturalistic laws of science.

pareidolia: The tendency to see patterns in random noise—for example, seeing a human face in the random features of a cloud.

pattern recognition: The phenomenon of perceiving patterns—whether in visual information, other sensory information, or even events or behavior. Humans generally have a great ability to recognize patterns and a tendency to see patterns even when they are illusory.

petitio principii: A Latin term for begging the question, or assuming one's conclusion in the premise of an argument.

phantom limb: An illusory limb that does not exist but that the subject can feel and even have the sense that they can move. It is commonly, but not exclusively, the result of amputation.

philosophical naturalism: The philosophical position that the natural world is all that exists—that there is nothing that is supernatural.

post hoc ergo propter hoc: Literally meaning "after which hence by which," a logical fallacy in which it is assumed that B is caused by A simply because B follows A.

post-modernism: A school of philosophical thought that treats all knowledge as equally valid social constructs or narratives.

premise: A fact that is assumed to be true, or treated as if it is true, as a starting point for an argument.

prospective study: A study that involves selecting subjects and then following them to observe their future outcome.

pseudoscience: A practice that superficially resembles the process of science but distorts proper methodology to the point that it is fatally flawed and does not qualify as true science.

psi phenomena: Alleged phenomena dealing with extrasensory perception—also called anomalous cognition—such as mind reading, remote viewing, and precognition.

psychosis: A psychiatric condition characterized by impaired reality testing.

P value: A statistical term referring to the probability that the results of a study would be what they are or greater given the null hypothesis—that the proposed phenomenon being studied is not true.

reality testing: A cognitive process by which the brain compares any new information to its internal model of reality to see if the new information makes sense.

recall: The act of bringing to the conscious mind memories stored in long-term memory.

reductio ad absurdum: A Latin term that refers to a legitimate logical argument in which a premise is taken to its logical, although absurd, conclusion. This can be a fallacious argument if the absurd conclusion is forced and does not follow inevitably from the premise.

regression to the mean: A statistical phenomenon in which large deviations from average behavior are likely, by chance alone, to return to more average behavior.

representativeness heuristic: The assumption or bias to believe that causes resemble effects. Therefore, for example, a large effect must have had an equally large cause.

retrofitting: Fitting predictions to known outcomes after they occur.

retrospective study: A study in which subjects are selected, and then data is gathered about their history.

Russell's teapot: A hypothetical teapot proposed by Bertrand Russell that is orbiting the Sun between Earth and Mars to make the point that not all claims that cannot be proven false should be accepted as true.

scientific skepticism: A comprehensive approach to knowledge that emphasizes critical thinking and science. Skepticism combines knowledge of philosophy of science, scientific methods, mechanisms of self-deception, and related fields to approach all claims to truth in a provisional and systematic way.

self-deception: The act of deceiving oneself due to a host of perceptual, cognitive, and memory biases and flaws.

sharpshooter fallacy: Choosing the criteria for success specifically to match the results that are already known.

short-term memory: Memory for immediate sensory or internal information that lasts from seconds to a few minutes.

sick building syndrome: A form of mass hysteria centering around a building that is believed to be the source of a mystery ailment.

sound: In logic, this describes an argument that has both true premises and valid logic, and therefore, the conclusion must be true.

source amnesia: The tendency to forget the source of information more easily than the information itself.

spam: Unwanted e-mail messages usually used for advertising or to spread rumors or propaganda.

split-brain experiment: An experiment on a subject who had the connection between their two brain hemispheres surgically cut that helped reveal the functions of the two hemispheres and how they work together.

statistical significance: A statistical term referring to the comparison of target and control groups in scientific studies; when the difference in outcome or a particular feature is greater than a predetermined threshold, then the results are considered to be statistically significant.

subconscious: Brain processing that occurs without conscious awareness.

supernumerary phantom limb: A phantom limb that is not simply a replacement for a missing limb but is experienced in addition to the four natural limbs.

symbolic community scare: A long-standing mass delusion that tends to wax and wane over years and is centered around a perceived existential threat to the community.

synesthesia: When more than one sensory modality is combined or when one sensory modality is interpreted as another, such as smelling colors.

systematic review: A review and analysis of all the relevant scientific studies published on a specific question.

tautology: In logical terms, this is an argument in which the conclusion simply repeats the premise and is, therefore, not a true argument.

theory of mind: A psychological term that refers to the ability to understand and think about the fact that other people have their own conscious existence with their own feelings and motivations.

transcranial magnetic stimulation (TMS): Technology that uses magnetic fields to either increase or decrease activity in specific regions of the brain.

transitional fossil: A paleontological term to refer to a fossil specimen that represents a species that lies phylogenetically between two other species or groups.

urban legend: A false belief or story that represents a common fear or anxiety in society and spreads largely through rumor.

valid: An argument in which the logic is proper and not fallacious.

witch hunt: The persecution of a person or group using accusations of heinous acts, or association with such acts, and using dubious investigating techniques designed to achieve the conclusion of guilt.

working memory: A type of memory that is distinct from short-term memory because it consists of information that the brain can manipulate, such as performing mental calculations.

Zyklon-B: The trade name for a form of cyanide gas that is used for delousing, but it is also infamously used by the Nazis during World War II to exterminate humans.

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